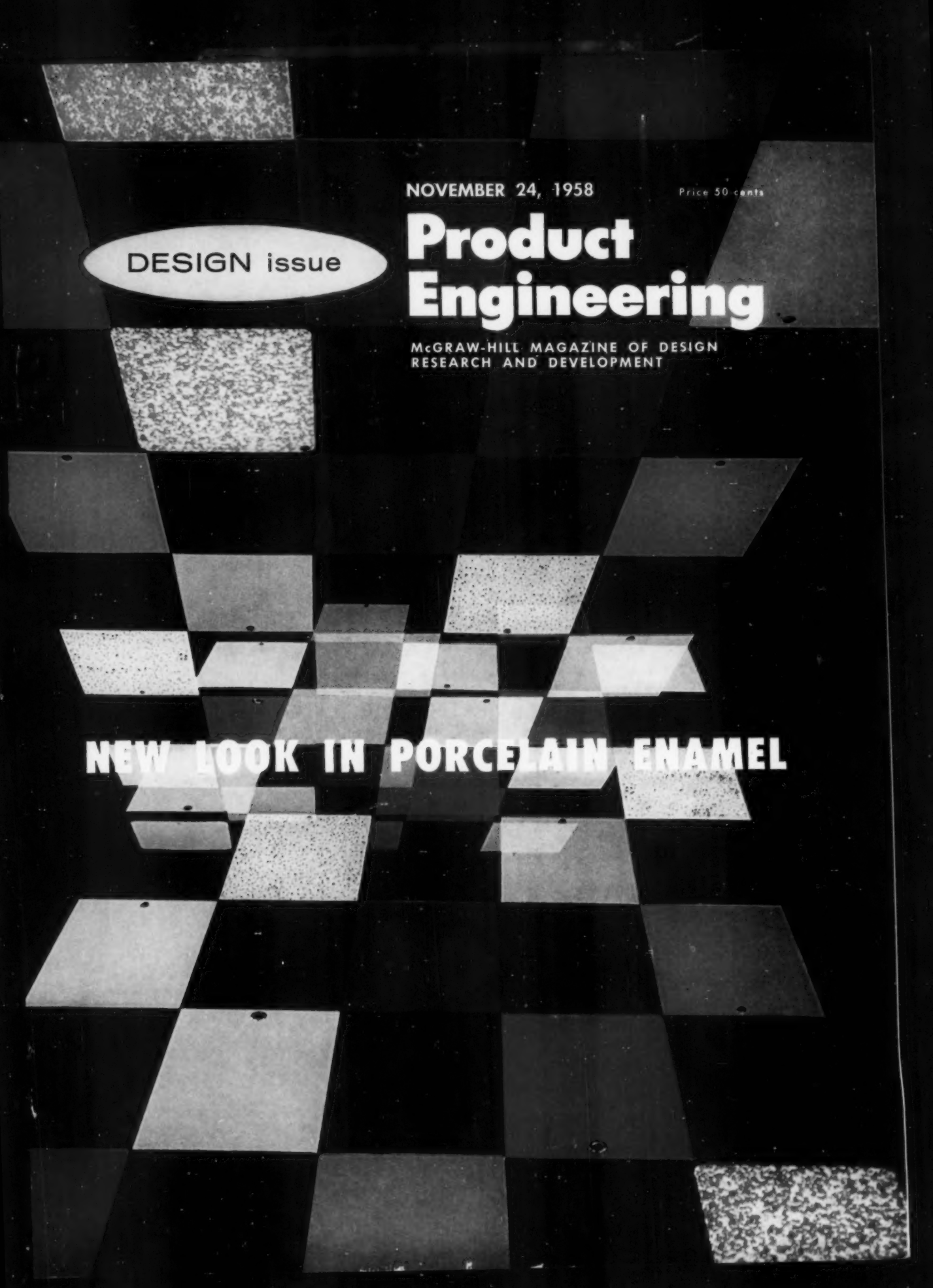

DESIGN issue
NOVEMBER 24, 1958
Price 50 cents
Product Engineering
McGRAW-HILL MAGAZINE OF DESIGN
RESEARCH AND DEVELOPMENT
NEW LOOK IN PORCELAIN ENAMEL

Every small worm gear unit is built to precision standards—as outstanding in quality and performance as larger size Clevelands.
Illustrated above are the 10 AT (left) and 00 D (right) speed reducers.

Enjoy the benefits of worm gear drives in smaller CLEVELAND speed reducers

WHEN you want a quiet, powerful, dependable drive for a small machine, choose a Cleveland Worm Gear Speed Reducer.

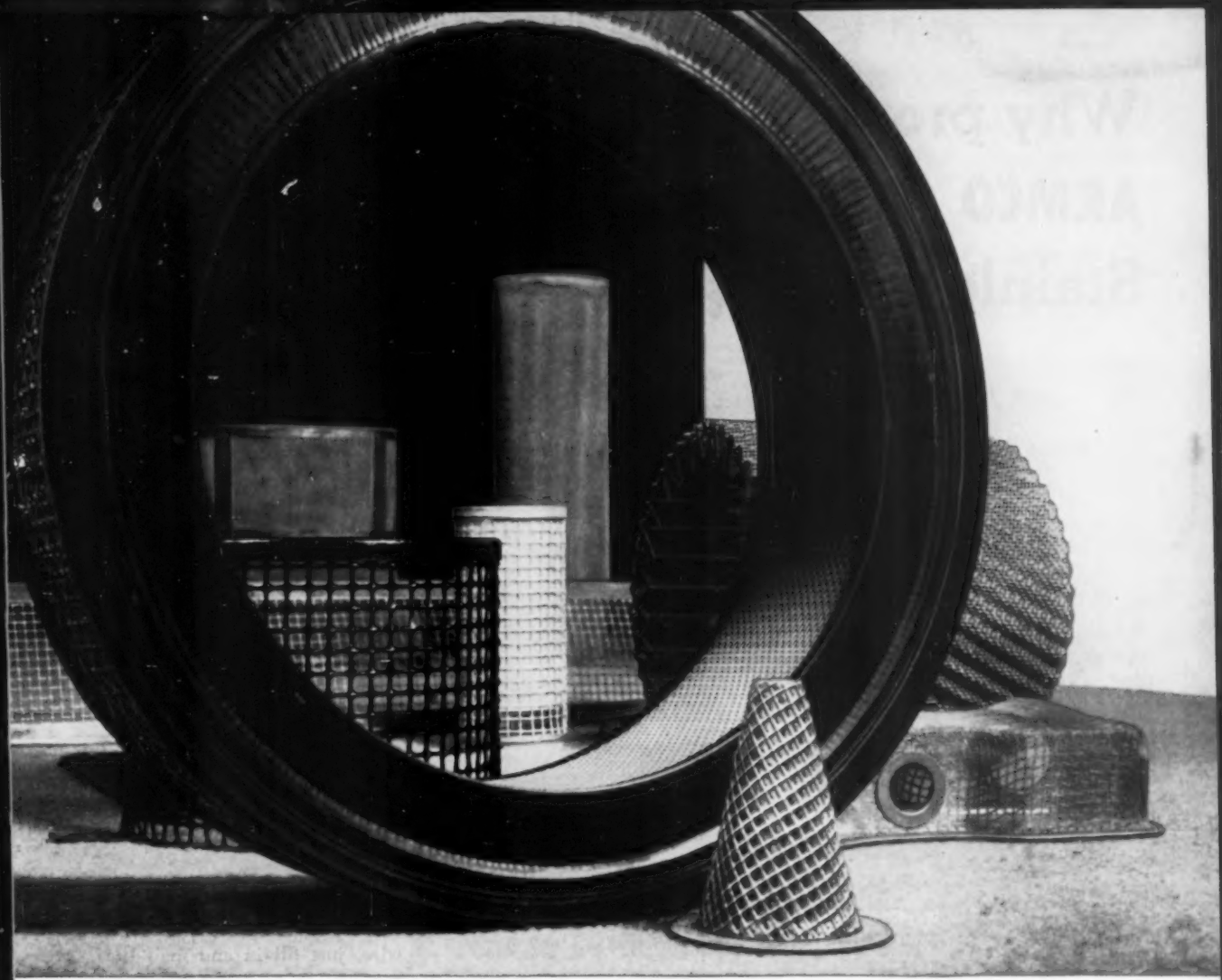
As built by Cleveland, the worm gear reducer is a drive of many advantages:

1. It is compact and inherently quiet, transmitting power with smooth, uninterrupted torque flow.
2. Its right-angled design saves valuable space.
3. It has a minimum of moving parts.
4. Shock load resistance and other factors of safety are high.
5. Rate of wear of case hardened steel worm on nickel-bronze gear is very low, insuring long life.

Write for Bulletin 114F which illustrates and gives engineering data on smaller size Clevelands—many now available for immediate delivery. The Cleveland Worm and Gear Company, 3279 E. 80th St., Cleveland 4, O.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

CLEVELAND
Worm Gear
Speed Reducers



How to **USE** wire cloth at lower cost

Today many companies are able to make wire cloth components, like these shown here, at lower cost than ever. The answer lies in new services, new developments worked out by the *Reynolds Wire Division* of National-Standard . . . ideas aimed at the more effective, less wasteful *use* of industrial wire cloth. For example . . .

5 SUGGESTIONS:

1. Check on wire cloth rolls 2 to 8 times normal length . . . for 2 to 8 times as much production in a single run. Fewer shutdowns. Less handling.

2. Consider pre-slit widths, plain or with woven-in reinforcement, as narrow as 1 inch or less, to meet your requirements exactly with minimum handling and waste.

3. Evaluate Reynolds' new palletized packaging. Less chance of damage. Faster, easier handling on arrival, in and out of storage and right to production operations.

4. Look into the many different weaves, meshes, metals, finishes and coatings . . . some unique with Reynolds . . . to make sure of the optimum specification for your requirement.

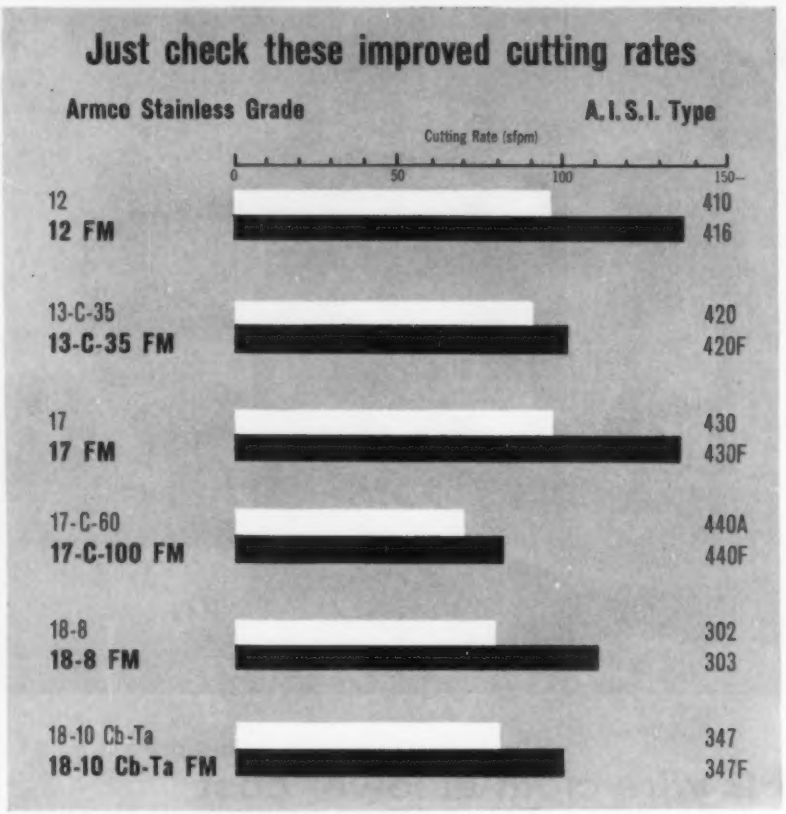
5. By all means take advantage of Reynolds' engineering and analytical service . . . nation-wide and unmatched in the industry. Time and time again it contributes to a better finished product at lower cost.

NATIONAL NS NATIONAL STANDARD **STANDARD**

DIVISIONS: NATIONAL-STANDARD, Niles, Mich.; *fine wire, stainless, music spring and plated wires* • WORCESTER WIRE WORKS, Worcester, Mass.; *music spring, stainless and plated wires, high and low carbon specialties* • WAGNER LITHO MACHINERY, Secaucus, N. J.; *metal decorating equipment* • ATHENIA STEEL, Clifton, N. J.; *flat, high carbon spring steels* • REYNOLDS WIRE, Dixon, Ill.; *industrial wire cloth*

CIRCLE 101 READER SERVICE CARD

Why production steps up with ARMCO FREE-MACHINING Stainless Steels



Here's the increased machinability you can about expect from some often-used free-machining stainless steels. All rates are based on speeds in automatic screw machines.

In service, the toughness of stainless steels gives them endurance that ordinary metals can't match. But in part-production, this very toughness can limit machining speeds. That's why Armco produces free-machining counterparts for many widely-used grades of stainless steel bar and wire. Small additions of certain elements make these special grades machine faster. Production rates jump.

TRY THEM

Here's how to prove it for yourself. If you now machine parts from a standard stainless steel, just contact your nearest Armco Sales Office or Armco Stainless Distributor. They will be glad to arrange for you to try out the Armco Free-Machining counterpart of the grade you are now using.

Or, if you would like more information about uniform-quality Armco Stainless Steel bar and wire, just fill in and mail the coupon.

• • •

In addition to stainless steel sheet, strip, plate, bar and wire, Armco produces these other steels for top-quality products: ALUMINIZED STEEL, ZINCGRIP®, ZINCGRIP PAINTGRIP®, Cold-Rolled PAINTGRIP, Enameling Iron, Electrical Steels, High Strength Steels, Welded Steel Tubing, and Long Ternes, as well as high-quality hot- and cold-rolled sheets.

New steels are born at Armco

ARMCO STEEL CORPORATION, 3008 Curtis St., Middletown, Ohio

SEND more information about Armco Stainless Steel bar and wire.

☐ I am interested in free-machining grades

NAME _____ TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE _____ STATE _____

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products

Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN, RESEARCH AND DEVELOPMENT

NOVEMBER 24, 1958 Vol. 29, No. 48

New Look In Porcelain Enamel 53... W E Pierce, Porcelain Enamel Institute
There is now a wide choice in colors; various textured surfaces can be had; and the new coatings offer valuable engineering properties. Chart describes the decorative processes and what they can do.

Designing an Epicyclic Gear 57... R J Willis Jr, General Electric Co
First step is determining the maximum number of planets the desired gear system can have. This is usually a time-consuming procedure. The author offers a speedier way.

Design Features in New Products 60... This machine tool has a sense of touch; focused, intense light substitutes for heating instrument.

More Surface Polish—Less Galling 63... W H Moore, Meehanite Metal Corp
Test results show why components should be worn-in before they take loads, and why cast irons are less likely to gall than the steels or brasses.

Money-saving Electromagnetic Relays 66... Ralph Probert, Potter and Brumfield
You can get super-performance switching devices but does the application justify the cost? Design will run into fewer troubles, too, if you keep this down-to-earth article handy as a guide.

The Case for Swaging 70... L A Whiting, The Torrington Co
Newer swaging machines have broadened usefulness of this high-speed method for shaping metal. Author gives tips on choosing suitable materials, and specifying shapes and tolerances.

DESIGN FILE

Packed Glands for High Pressure 74... J L Thomson, England
Second part of this foreign digest gives 11 design ideas covering spacers, leak-off points and radial sealing.

Chart Analyzes Sinusoidal Motion 77... K W Maier, Olin Mathieson Chemical Corp
Quick method finds speed, acceleration, force and other values for spring-supported masses.

DEPARTMENTS

Interesting to Note	5	Editorials	51, 72
Developments to Watch	21	Significant Components	81
The Engineering Week	23	Catalogs and Bulletins	98
Coming Events	27	Design Abstracts	107
Reader to Editor	28	New Books	108
Design Perspectives	49	Current Reprints	115

TYPE S*

Adjustable or non-adjustable. Positive-acting, single-stud (shown) or nozzle mounting. Operation to 600°F. Ratings: 15 amps at 115 volts AC, 7 amps at 230 volts AC. Spade or screw type terminals. Bulletin 1000.

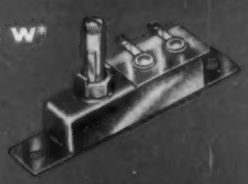
TYPE SA*

Adjustable or non-adjustable. Also Type SM* Manual Reset style. Snap-acting with electrically independent bimetal. Also single-pole, double-throw. Non-inductive-load rating 15 amps at 115 volts AC, 10 amps at 220 volts AC. Spade or screw terminals; single-stud (shown) or nozzle mounting. Bulletin 2000.

TYPE A*

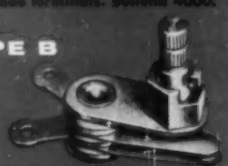
Semi-enclosed and hermetically sealed styles. Insulated, electrically independent bimetal disc gives fast response and quick, snap-action control. Operation from —10° to 300°F or higher on special order. Various mountings and terminals. Rated at 6½ amps at 115 volts AC, 2 amps at 230 volts AC and 28 volts DC. Bulletin 3000.

TYPE W*



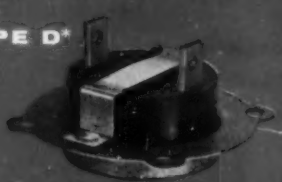
Adjustable and non-adjustable styles. Snap action. Operation to 300°F. Rated at 5 amps at 115 volts AC, 3 amps at 230 volts AC. Screw, solder and spade terminals. Bulletin 4000.

TYPE B

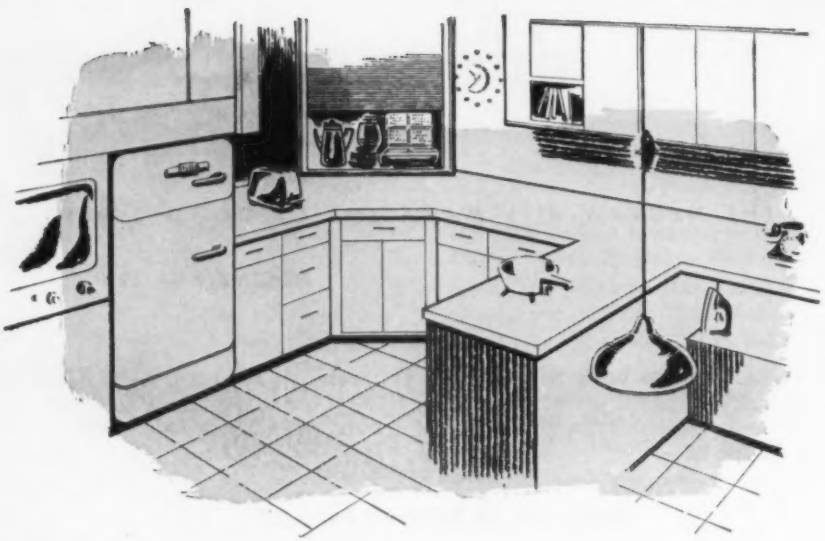


Adjustable and non-adjustable styles. For applications where heat generated by passage of current through bimetal is desirable. Various terminals; single-stud (shown) or nozzle mounting. Operation to 400°F. Normal rating: 5½ amps at 115 volts AC of 40 cycles and higher. Bulletin 9000.

TYPE D*



For laundry dryers or other surface and warm air applications. Automatic (shown) and manual reset types. Snap-acting disc type U.L. approved for operation to 300°F. Rated at 25 and 40 amps at 120-240 volts AC. Open or Enclosed styles. Bulletin 8000.



STEMCO THERMOSTATS

the complete line for appliance and apparatus use

The best way to check rising thermostatic control costs is to check up on the Stemco thermostat line *while your product is in the planning stage.* Since the Stemco line is the broadest line in the industry, there is a good chance that a standard production-line Stemco thermostat—or a minor variation thereof—will fill your special requirements *exactly.* That saves design and "lead" time... saves on development costs ... gives a *proven unit at a realistic cost.*

AA-6294

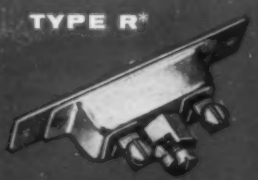
TYPE M*

Semi-enclosed and hermetically sealed styles. Electrically independent bimetal disc type for appliance and apparatus applications from —10° to 300°F. Ratings: 5 amps at 115 volts AC, 4 amps at 230 volts AC and 28 volts DC. Virtually any type terminal. Bulletin 6000.

TYPE H

Positive-acting, adjustable, for fry pans, skillets and other appliances. Fail-safe, open in low to 500°F in high. Rated at 1650 watts at 115 volts AC. Bulletin 10,000.

TYPE R*



Adjustable and non-adjustable styles. Positive acting for operation to 600°F. Rated at 15 amps at 115 volts AC, 4 amps at 230 volts AC. Screw terminals. Bulletin 7000.

STEMCO THERMOSTATS

STEVENS manufacturing company, inc
Lexington and Mansfield, Ohi

*Refer to Guide 400 EO for U.L. and C.S.A. approved ratings. Patent Applied For.

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Interesting to Note . . .

A New Look at Porcelain

Benvenuto Cellini, great 16th Century artist, decorated and inlaid some of his gold masterpieces with "porcelain." The famed Cellini cup, for example, was highlighted with "porcelain" elements composed of china clay, fine white sand, and powdered glass.

Two centuries later, a German alchemist, Johann Boettger, was experimenting at the royal laboratory of Frederick August II. While working with kaolin, then a wig powder, he discovered a paste that, when glazed, had a deep, rich beauty. This was a true porcelain—in 1711. To keep him from revealing the secret, he was compelled to work in semi-captivity under guard.

The secret was, however, eventually revealed, and porcelain and porcelain enamels appeared in prized objects d'art. Their color and brilliance were the important elements. But, through the decades, porcelain enameling become a mundane, workaday process, and these characteristics were almost lost. The frits ended up mostly on housewares and in a limited color range. Now, however, with new colors and textures that are controllable, many architectural and decorative uses have been developed. These include a colorful protective surface for structural aluminum. The industrial-design applications are increasing, too, so we've provided both a cover and a 4-page full-color story in this issue. For the story, see page 53.

The Light That Heals

For centuries, the eye had to adjust to flickering flames, deep shadows and just plain bad light. Movie versions of mid-Victorian balls in colorful costumes seem to forget that they weren't illuminated by klieg lights but by massive chandeliers containing thousands of candles—or perhaps the ballroom would be ringed with oil lamps. There were more dancing shadows than dancing belles and beaux.

When Edison perfected the incandescent lamp in 1879, the era of reading by flame came to an end. Although many rural areas stayed with gas and kerosene, the electric light began to appear in more and more homes. But acceptance of the electric bulb came slowly. After Edison's first public showing, New York papers reported the event as an interesting experiment in science.

(Continued on page 7)

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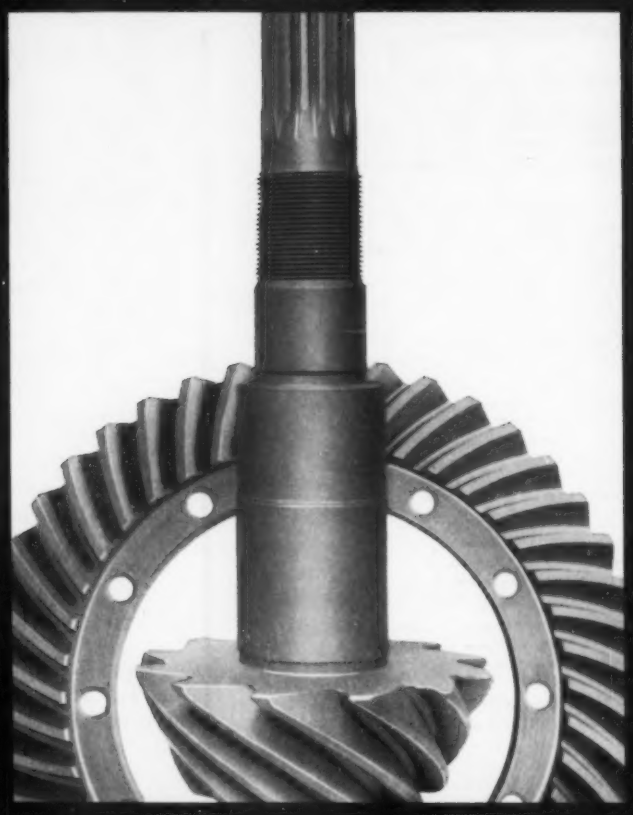
←CIRCLE 103 READER SERVICE CARD

how standard AISI-SAE MOLY CARBURIZING STEELS help Pontiac 3 ways



After extensive testing, Pontiac adopted the 4520 type for ring gears and pinions in its 1956 model and has used this grade ever since.

IN PURCHASING

AISI-SAE 4520 is more economical than the previously used carburizing steel with lower molybdenum content.

IN PRODUCTION

AISI-SAE 4520 has machinability commensurate with the previously used carburizing steel and can be annealed with a simpler practice.

IN QUALITY

AISI-SAE 4520 gives a higher case hardness after carburizing and quenching than the previously used carburizing steel.

AISI-SAE 4520 is now a standard grade. Ask your regular steel supplier about it.

CLIMAX MOLYBDENUM CO.

A Division of
American Metal Climax, Inc.
500 Fifth Avenue, New York 36, N. Y.

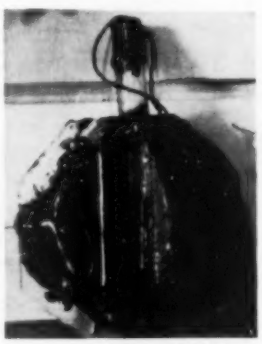
It was never initially suggested that an era was opening. Edison's uphill climb turned out to be only a plateau. He still had to sell his idea.

Today, intense light is being used to improve some eye conditions that result from separation of the retina. Design details on p. 62 show how light is focused down into the eye to weld a detached retina.

Sealing Wax and Cyclotrons

Soon after the eerie glow of radium led the Curies to the discovery of this potent element, physicists and chemists throughout the world began trying to understand the new science centering around radioactivity. Names like Chadwick, Rutherford, Bohr and the Joliet-Curies appeared in the scientist's bible, *The Physical Review*. Slowly, pieces of the atomic puzzle began falling into a pattern; slowly, atomic physics came into its own. The new concept of materials would soon affect engineers in all fields of study. For instance, the mystery of galling (p. 63), was found to be more than erosion at work; it was solved with an understanding of molecular movements. Those engaged in chemistry, biology, geology and other fields of knowledge had to rewrite their textbooks. Yet, nuclear research was still in its primitive stages. A physicist had to borrow radioactive materials from cancer hospitals for study, then return it several hours later.

In 1929, a professor at the University of California, Dr. E. O. Lawrence, tried to produce artificial radioactivity in his laboratory. During the Christmas recess he took a magnet, some brass scrap, several pieces of window pane and sealing wax, then built a device (at right) to concentrate streams of elementary particles. This giant step in nuclear research won Dr. Lawrence the Nobel Prize in 1939 for conceiving and building the world's first cyclotron.



Courtesy: U. of Calif.

Around in Circles

There is an age-old adage, "If the facts don't fit the theory, change the theory." But too often it's easier to keep the theory and change the facts. Then again, the theory that does explain a set of facts may later prove dead wrong. For centuries, astronomers had theories to prove the workings of the solar system. A flat earth with animals and gods waiting at the edge was one of the old wives' tales that some of the stargazers couldn't swallow. So, 400 years before Christ, two such astronomers, Eudoxus and Callippus, explained that the earth is not only round but the center of the universe, and all celestial bodies revolve around us.

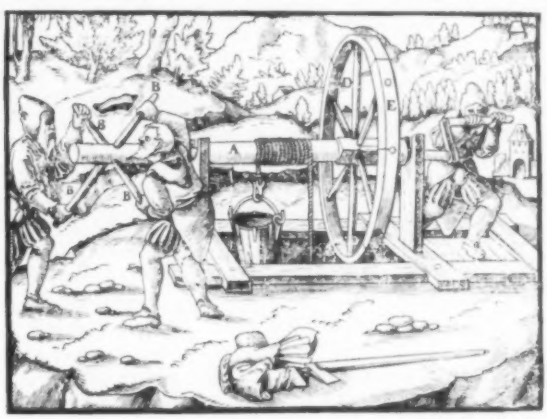
Later facts, however, proved them wrong: It was observed that planets do not move in concentric circles about the earth. Confusion reigned for several centuries until Ptolemy, in 150 AD, confirmed part of the Eudoxus hypothesis—the earth is the center of the universe, but planets don't revolve about the earth's center. Ptolemy said each planet revolves in a small circle or epicycle which in turn travels around a large circle whose center is near but not at center of the earth. Ptolemy's elaborate explanation, not too dissimilar to a planetary-gear system of today (p. 57) proved fairly accurate for its time. Not until the 17th century brought Copernicus and Kepler did a superior theory overrule Ptolemy.

The Miner's First Textbook

From *Accordion World* to *Zoo Life*, there is a publication somewhere to fit the requirements of any trade. It hasn't always been thus. For hundreds of years a craft would be passed on from father to son. This all changed with the first technical publication.

In 1556, a Saxon named Georgius Agricola published a book entitled *De Re Metallica* which became the leading textbook for miners and metallurgists for nearly two centuries. The book was translated into English by that mining engineer and statesman, Herbert Hoover, in 1912. It greatly contributes to the history of science with its descriptions of mining methods, metallurgy and mineral extraction. Through Agricola, Europe learned how to rid a mineshaft of water, cope with miner's diseases, grind, stamp and refine metals. He explained that the development of the horse collar, tandem harness and horseshoe "did more to eliminate slavery than all the preachments of saints and philosophers."

He described, with sketches, mechanical principles like that of the windlass—the same principle is incorporated today in steering mechanisms and even a power amplifier in a control system for automated machines (p. 60).



From *De Re Metallica*

Shown above is an ancient, heavy-duty windlass with a flywheel that had to be operated by three men. It was used to extract ore from a mine. Lead weights were sometimes added—to "depress the spokes by their weight and increase the motion." The principle of inertia had yet to be established.

—Benedict A. Leerburger Jr

Versatile stop clock measures to 1/100 second

Today's product designer, control systems engineer, nuclear physicist, and graphic panel manufacturer have a common need—an instrument capable of measuring elapsed time to a hundredth of a second, with an accuracy better than 0.02 of 1%.

Wide field—wide requirements

But there the sameness ends—the nuclear physicist needs a hermetically sealed device for remote control; the product designer requires load switches and local pushbutton reset; the graphic panel man wants smart appearance. The lab technician wants a portable model. The military asks for the smallest unit consistent with reliable readings, while the sports event timekeeper must have a large dial.

How can you meet these diverse requirements? Well, here's the answer to that question—a product of Cramer's experience and knowledge of precision timing.

Accuracy for everybody

You select a small, powerful and inherently accurate drive motor, add a 110-tooth positive clutch and apply it on the high-speed shaft. Back it up with a potent relay. When the signal comes, the unit responds instantly, and we have *accuracy*.

All-electric operation for flexibility

Add heart cams on the mainshaft and a rugged solenoid to belt them home within 1/10 second after the reset switch is operated. Now we have *electrical reset*, either remote or local.

For *versatility*, provide for load switches with cams on fast or slow pointer shafts. Cut and set at the factory, cams will offer a variable number (and duration) of pulses per second or minute, or with load switches wired in series, the unit can be used as a highly precise time delay relay or interval timer.

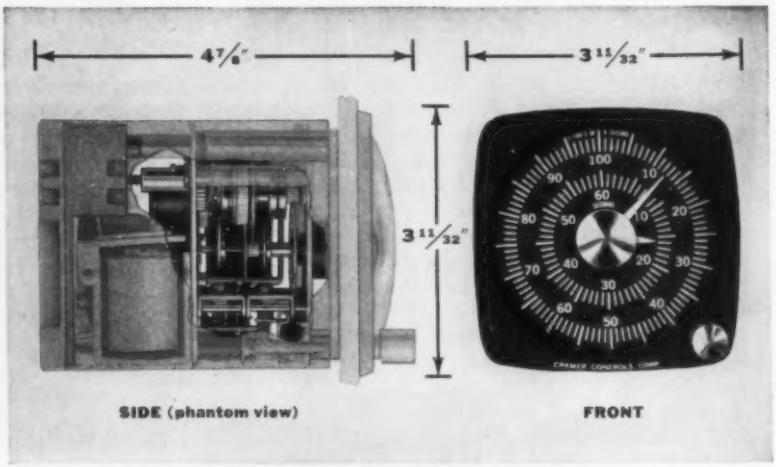
Commercial or Mil-Spec housings

Now let's enclose the mechanism. Commercial housing is dust-tight and has a 12-place terminal block. Also developed: a militarized model to withstand high vibration, shock and severe environments. A deep-drawn solder-sealed enclosure with 14-pin glass-beaded header, evacuated and hermetically sealed will do it.

Dials, pointers — Loewy styled

What's left? The business end of things — dial and pointers. Let's tackle this for readability, and at the same time, shoot for eye-appeal. This time we'll go to the *styling* experts — famous industrial designers, Raymond Loewy Associates. They come up with the last word in human-engineered dial-pointer combination for fast, exact readings. Frame it with a pleasing bezel that can be finished to match or harmonize with your panels.

Now it looks like the precise instrument that it is — the new Cramer Type 691 Time Totalizer. Bulletin PB 691 tells more about it. For detailed information and complete specifications, write Cramer Controls Corp., Box 7, Centerbrook, Connecticut.



TYPE 691 PRECISION ELECTRICAL STOP CLOCK

	Total Range	Outer Scale	Inner Scale
		Each Division	Each Division
TIME RANGES:	60 sec.	.01 sec.	1 sec.
	60 min.	.01 min.	1 min.
	60 min.	1 sec.	1 min.

RATINGS: Motors — all standard voltages at 50, 60 and 400 cps, and 28 volts DC (chronometrically governed); clutches and solenoids — all standard voltages at 50 and 60 cps, and 28 volts DC.

ACCURACY: Within .01 second for 60-second units, and within .005 minute for 60-minute units.

ELECTRICAL RESET: Actuated either by momentarily pressing pushbutton on timer bezel, or by closing a remote switch. Timer pointers return to zero within 1/10 second.

LOAD SWITCHES: One or two, optionally available, SPDT, rated 5 amperes at 115 and 230 volts AC (resistive), 2 amperes at 28 volts DC.

CAMS: Optional, to operate load switches. Precision-cut to exact time specifications, they can provide a series of electrical pulses during timing, or transfer switch contacts at any point or points within the time range of the unit.

EXTERNAL CONNECTIONS: All connections to motor, clutch, reset solenoid and load switches are brought out to numbered terminals.

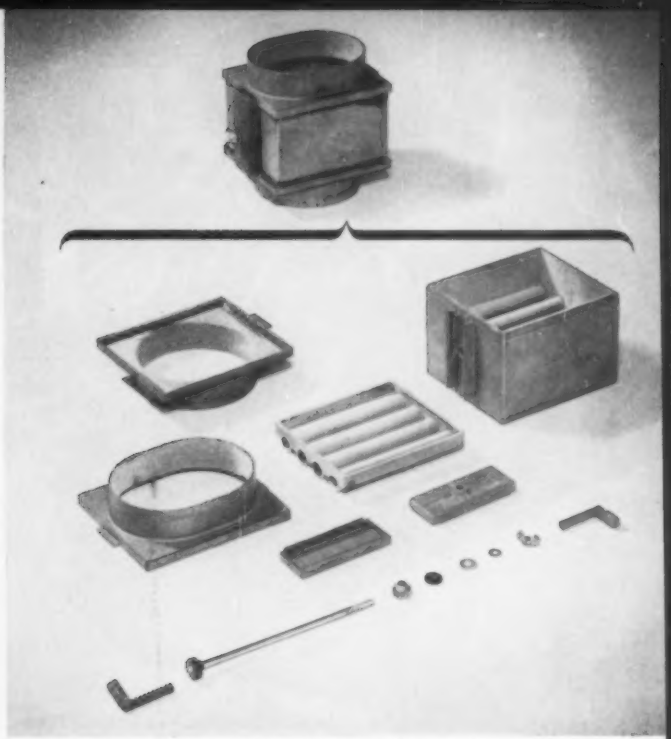
MIL-Specs: Hermetically-sealed military units meet vibration, shock and environmental requirements of MIL-E-5272A.

TALK IT OVER WITH

CRAMER CONTROLS CORPORATION

CIRCLE 106 READER SERVICE CARD→

D-J casts, finish machines, plates and assembles door hardware for a Mid-West merchandiser. Eleven zinc parts are die cast . . . then tapped, reamed, faced and plated. Other parts are drawn and stamped as needed. Springs, lock washers, screws, locks and keys are purchased. Finally, D-J assembles and packages the units.

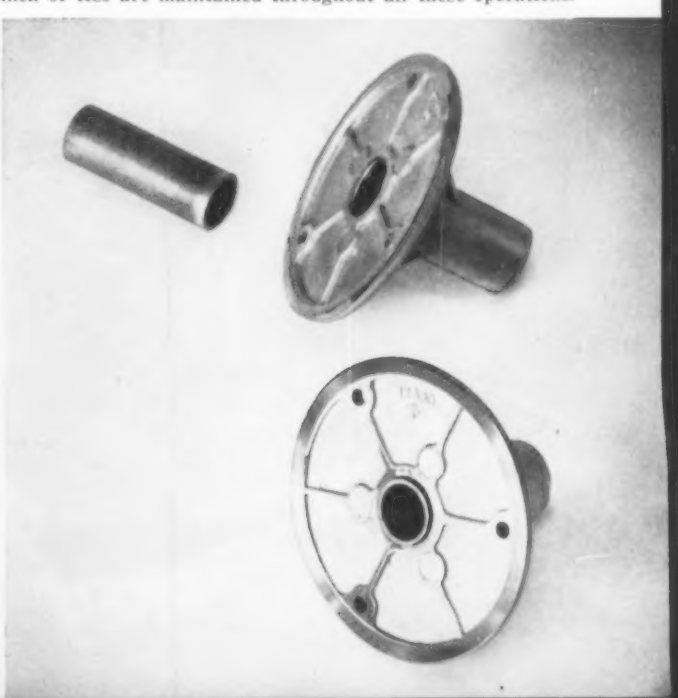


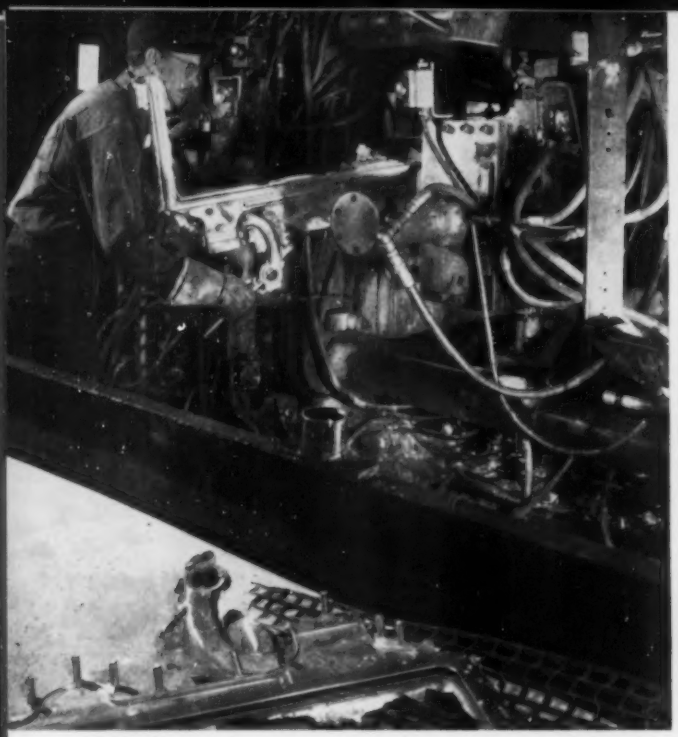
D-J die casts, machines, flock finishes and assembles damper for York Corporation. Unit is a complex high precision assembly of ten die cast parts including racks, pinions, and pistons. D-J flocks interior parts before assembly, seals seams to air-tightness under pressure. Exterior surfaces are carefully alodined.

3 pages of proof Doehler-Jarvis can do more for you than die cast parts...

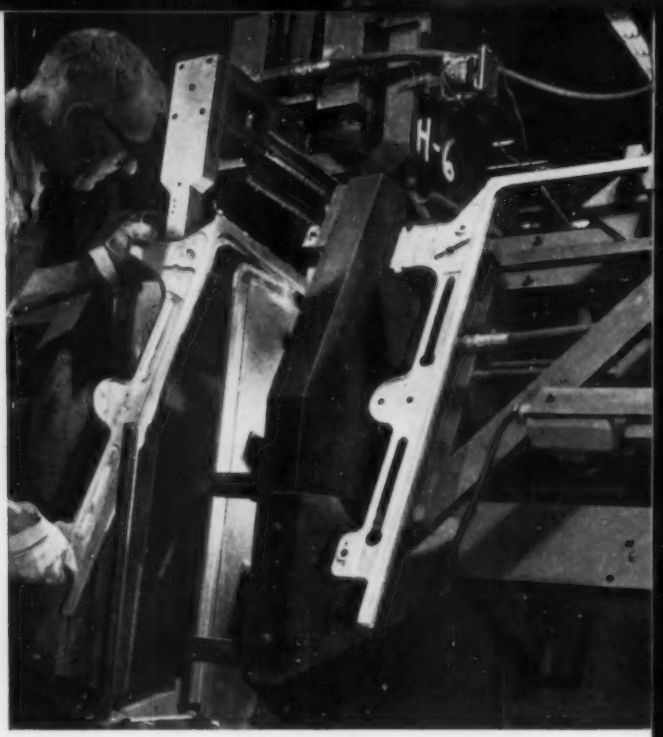
D-J casts, profile shapes, taps and electro-statically paints TV set parts for Radio Corporation of America. Ready-for-assembly die castings are by far the lowest-cost way to produce lightweight metal bezels and glass retainers for RCA Victor TV sets. Their dimensional stability speeds assembly.

D-J casts, machines, and assembles turntable hubs for well-known phonograph manufacturer. Hubs are trimmed, turned, slotted, reamed and fitted with bearings. The bearings are then chamfered and sized. Tolerances of 0.001 inch or less are maintained throughout all these operations.





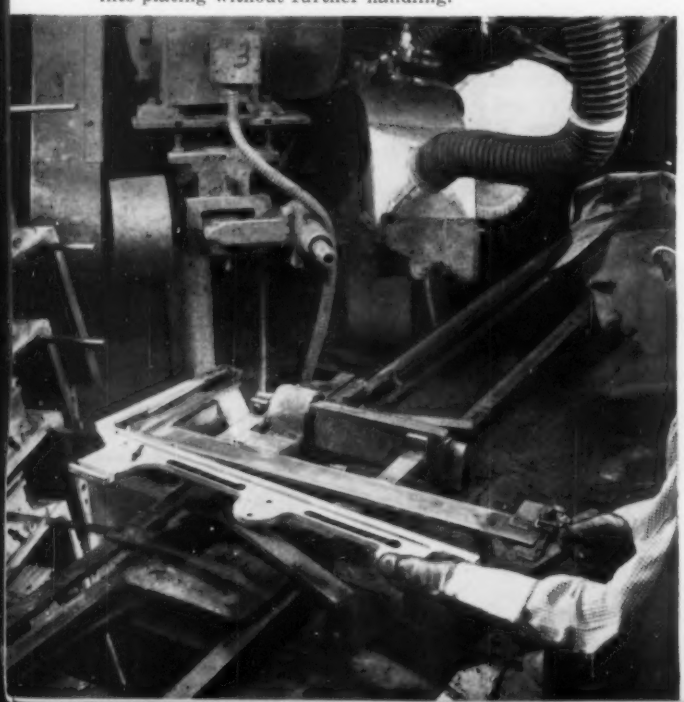
1 **Operator removes die cast zinc main channel** for Lincoln or Continental window assembly from large 48″ casting machine. Part is quenched in cooling solution then conveyed to trimming. D-J is now researching production techniques on giant 72″ machine, world's largest.



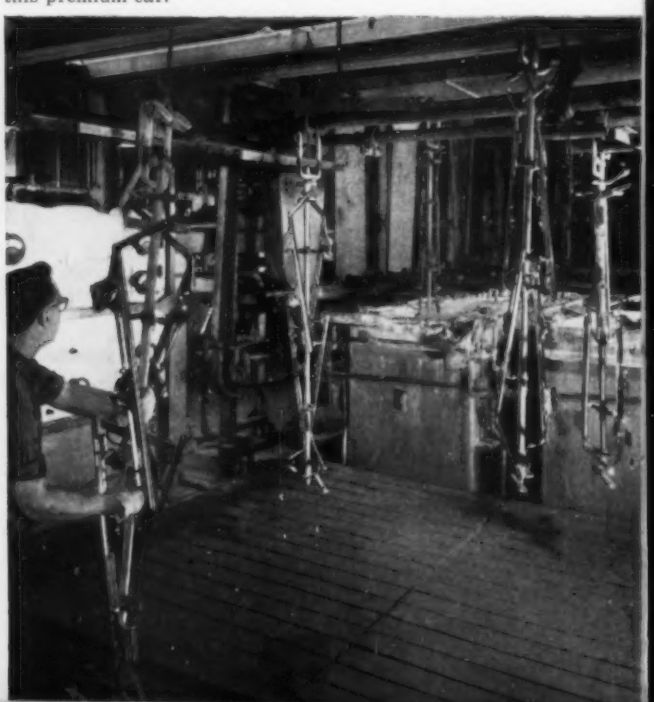
2 **Ingenious double-acting trimmer removes gate,** trims flash, finishes slots, taps 3 holes. Notice jig at right miters corner of frame. Scrap metal is collected, re-melted, re-refined and re-used. Minimum metal consumption is a big advantage of die casting.

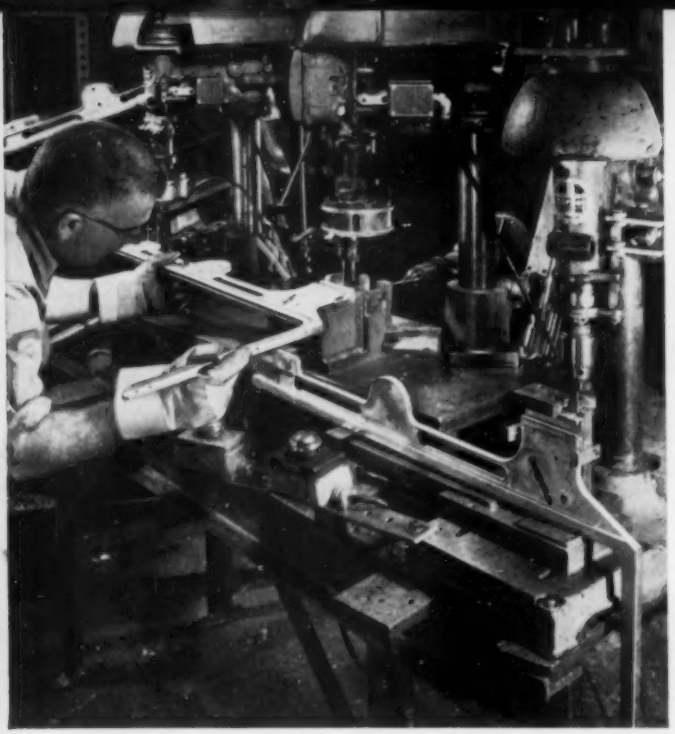
...D-J makes machines, plates, puts together

4 **Buffing, too, is set up for maximum economy.** Part is snap-clamped to device that positions it automatically for buffing wheels. When leaving fast-moving buffing lines, parts are racked and processed by conveyor through degreasing into plating without further handling.



5 **"Christmas trees" carry channels through plating.** Part is given optimum copper, nickel, chrome thicknesses using an automatic "plate-on-plate-off" current sequence that develops unusually high quality long-lasting finish desired for this premium car.





3 **Ganged machines complete drilling, tapping, reaming.** Behind operator you can see a universal work toting device. Removable pins support work and present it to operator prepositioned for speediest handling. (For another view of device, see following picture.)

Not everyone knows that Doehler-Jarvis does extensive machining, finishing and sub-assembly work as well as die casting.

But it's true. Every Doehler-Jarvis Plant (8 in the U. S. and Barber Die Casting in Canada) mass produces sub-assemblies, as well as die casting and finishing basic parts. And you can rest assured, costs undercut those that customers might achieve in their own plants.

Costs are bound to be low. Doehler-Jarvis has in abundance versatile machining, metal forming and joining equipment plus finishing facilities that are unique. Experienced design, purchasing and production personnel, too. Everything needed to set up economical, continuous production, assembly, and packaging lines.

a window assembly for the Lincoln Continental

6 **Window is glazed and finish assembled in special jig.** Here die cast channel, glass and other parts (some made, some purchased by D-J) are put together and weather sealed. Packaged part is shipped both to the Lincoln and Continental plants and to distributor warehouses.

There are other savings, too . . . savings in *your* plant. Less tooling, for example. And you receive a responsibly inspected, fully functional sub-assembly ready for immediate use. Many D-J customers take delivery only on sub-assemblies needed for basic production. Spare-part production goes directly to customer's distributors.

Makes sense, doesn't it? Especially when you see, as in these three pages of pictures, how D-J handles typical production work.

Maybe you could push your costs down this way, too. Care to talk it over?

Doehler-Jarvis
DIVISION OF NATIONAL LEAD COMPANY
General Offices: Toledo 1, Ohio

In Canada:
Barber Die Casting Co. Limited
Hamilton, Ontario

Reliability—Everyone has a different picture of reliability. To millions of us, it means an unthinking faith in the slender steel ropes that hoist an elevator car. To the captain of a ship, it's a staunch steel hull that will resist the wrack of any storm. To the policeman on the beat, it's the oil-smooth action of a steel revolver that must never fail.

So it is that whenever man decides to make something that is completely reliable, he usually makes it from steel. The reason is simple: steel is the strongest, toughest material on this planet that can be bought at a reasonable price.

More than that, it's so easy to *use*. With heat treatment, most steels can be made soft enough to work, then strong enough to carry the load, then tough enough to take the pounding of any application. With many steels, you can achieve 100% efficient welded joints. All this in a material that is universally available, in an infinity of grades, shapes, sizes, finishes and preforms.

Ironically, the great *variety* of steels often causes trouble for the designer. No matter what combination of properties you need, no matter what the application, there is theoretically one best steel for the job. Finding it among the great family of Carbon, High Strength, Alloy and Stainless Steels can be a problem unless you have a skilled metallurgist on your staff, or unless you take advantage of the free services of a company that has invested hundreds of millions of dollars in steel research–this is United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

United States Steel Corporation • American Steel & Wire • Columbia-Geneva Steel • National Tube
Tennessee Coal & Iron • United States Steel Supply • United States Steel Export Company

USS United States Steel

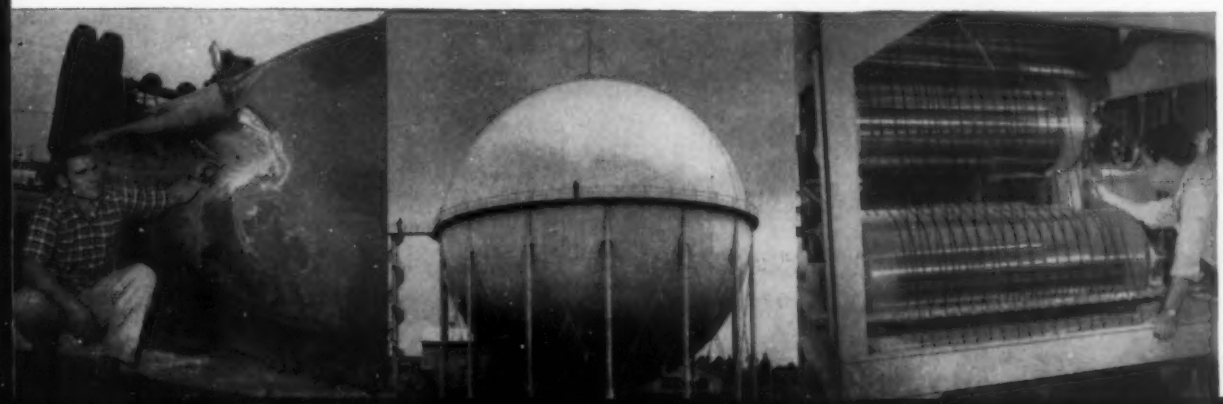
STEEL FOR DESIGN

Lower Left—Problem: Combine maximum pay load and safety in gasoline tank trailer. Solution: Tuttle Mfg. Co. in Los Angeles recommended USS COR-TEN High-Strength Low-Alloy Steel, well known for its ability to increase pay loads without sacrificing strength or reliability. Pay-off: Entire side of tank was caved-in in freeway crash, but the COR-TEN Steel didn't crack or tear. Cargo was saved and possibility of fire averted.

Lower Middle—Problem: Build completely reliable high-pressure natural gas storage vessels for Tokyo Gas Works Ltd. and save on steel. Solution: Vessels were built from USS" T-1" Constructional Alloy Steel. Plates were cold-formed and welded with a 90% joint efficiency factor. Pay-off: Due to the high allowable working stress (36,000 psi), they saved 1,720 tons of steel.

Lower Right—Problem: Design for a textile plant a 100% continuous steam process for vat dyeing that would insure exact color fidelity. Solution: Stainless Steel—its dense surface insures ease of cleaning, complete absence of color contamination. Pay-off: With the old equipment, dyeing was limited to one shade because it couldn't be adequately cleaned. The new Stainless equipment simply needs to be flushed out with hot water and it is clean enough for a new color.

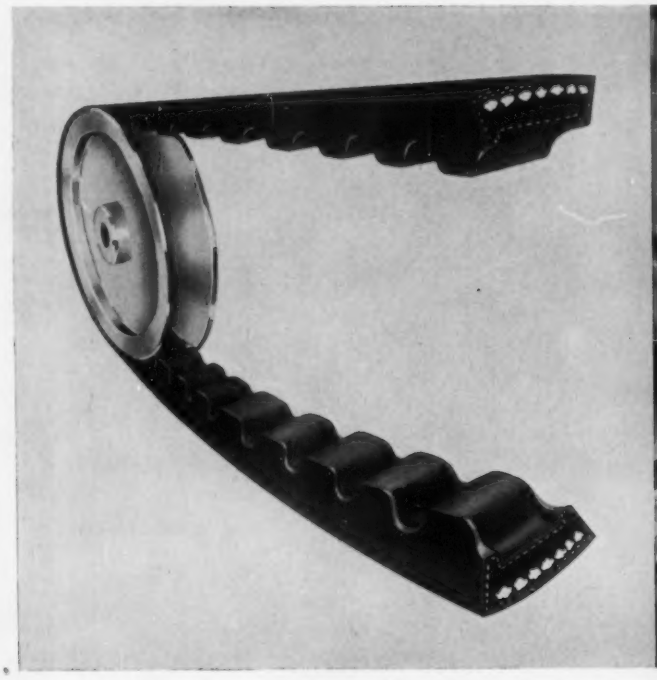
USS, "T-1" and COR-TEN are registered trademarks

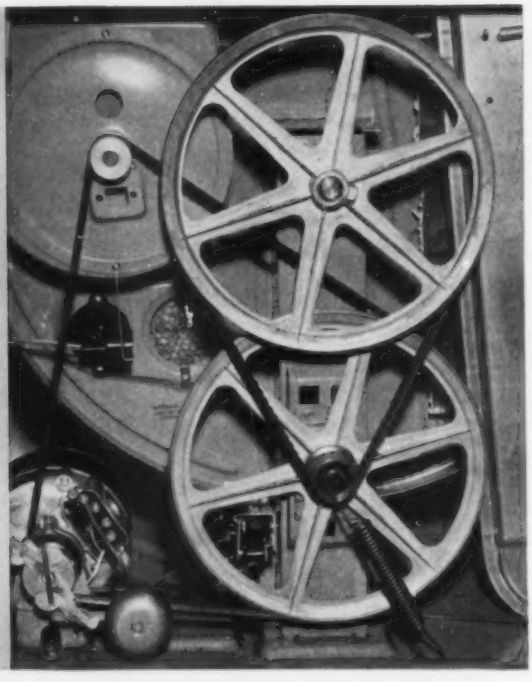


CUT COSTS, IMPROVE DESIGN AND PERFORMANCE WITH R/M PRODUCTS

RUBBER

Write today for free booklet shown: full details on a wide variety of industrial rubber products.
Manhattan Rubber Division, Raybestos-Manhattan, Inc.
Passaic, N.J.





NOW...A NEW DESIGN IN COG V-BELTS

Outlasts Other Belts as Much as 8 to 1

R/M introduces the new CX Cog V-Belt . . . *the only fully molded, fully jacketed cog belt*. Extensive tests have proved it outperforms, outlasts other makes of belts as much as 8 to 1. Fully molded and full fabric cover prevents flex-cracking, improves fatigue resistance, has less distortion because of lateral stability, maintains more effective length. It's the ideal cog belt for small pulleys where flexibility and ruggedness, with extremely quiet running, are important factors.

Other R/M V-Belt Designs

R/M engineering makes other V-belts to meet a wide variety of light and heavy duty requirements. For example, R/M FHP V-Belts eliminate troublesome vibration problems on motorized appliances, air conditioners, power tools. An exclusive molding process positions and controls every belt part to assure balanced belt power delivery without whipping or slapping.

On heavy duty multiple belt drives, Condor V-Belts with flat sidewalls assure *more* grip, *less* slip . . . longer belt life. (Write for Bulletin 6868).

For extra horsepower, R/M Super-Power V-Belts transmit 40% more power than conventional V-belts. You can increase drive power without changing drive design—or meet specifications with *fewer* belts. (Write for Bulletin 6628).

Space saving, no matching problems, and other advantages of the patented R/M Poly-V Drive, a revolutionary new concept in heavy duty power transmission, are detailed in a special Bulletin No. 6638.

Let R/M rubber specialists work with you on V-belts, transmission or conveyor belting, rubber hose, molded or extruded parts.

R/M

Brake Blocks, Linings and Clutch Facings

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

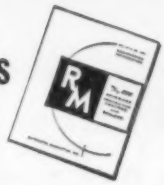
Industrial Drive Belts

Industrial and Automotive Hose

Conveyor Belts

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

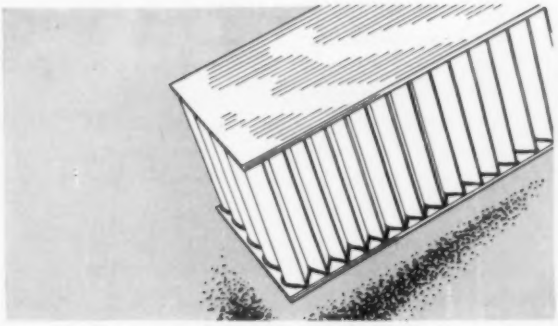
ADHESIVES



Send today for free copy of R/M Bulletin No. 700 on Ray-BOND adhesives, protective coatings and sealers.
Adhesives Department
Raybestos-Manhattan, Inc.
Bridgeport, Conn.

PACKINGS

Complete information on packings shown and many others is given in free booklet. Send for it today.
Packing Division,
Raybestos-Manhattan, Inc.
Passaic, N.J.



Resin-treated paper bonding to metal saves weight in this honeycomb.

Bonding polyethylene plastic firmly for use in sewer and irrigation pipe.

R/M Fabric Piston Cups R/M Vee-Flex Rings

Cutting Costs—and Corners in Product Assembly

With costs up and profits down, today is a better time than ever to check the advantages of adhesive bonding.

R/M Ray-BOND® Adhesives are now speeding assemblies and saving money in a broad range of different applications. Ray-BOND Adhesives have excellent bonding qualities and heat stability. They resist temperatures from −80°F to +700°F—give superior performance in meeting widely varied requirements, under many different destructive liquids, gases, atmospheres and physical conditions. And they have an impressive record for simplifying assemblies that were formerly difficult or impossible.

With over 20 years' pioneering in the production of bonded assemblies and the manufacture of adhesives and coatings, Raybestos-Manhattan is in a special position to demonstrate what adhesive bonding could do for you. Write for more specific information on your business letterhead now.

Controlled molding assures dimensional uniformity in R/M Piston Cups and "V-Rings"

R/M piston cups for hydraulic and pneumatic cylinders are designed and precision molded from a wide variety of modern synthetics to give maximum service with a minimum of friction. The clearly defined contours and cleanly trimmed edges assure strict adherence to industry's standard sizes. They are produced in varying degrees of hardness for pressures up to 1500 psi. Our engineers will gladly recommend the proper R/M piston cup for your specific operating conditions.

R/M Vee-Flex® packing rings, for use on steam or air rods, hot oil pumps, hydraulic cylinders, rams, presses, lifts, and a wide variety of other equipment, and precision molded in five types in varying degrees of hardness. They are self-sealing and self-adjusting for pressures up to 1500 psi.

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • Paramount, Calif. • No. Charleston, S.C.
Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

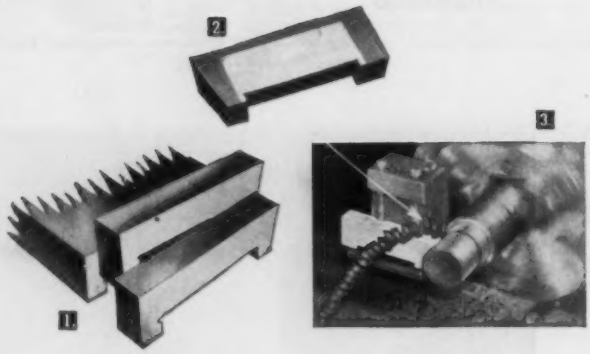
Asbestos Textiles

Industrial Adhesives

Teflon Tape, Packings, Sheets, Rods, Tubes

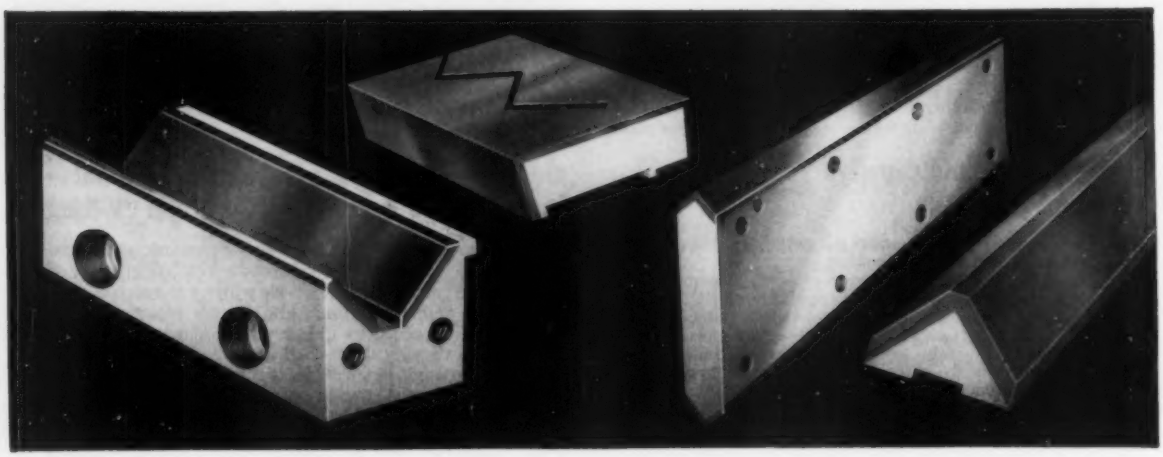
Engineered Molded Rubber and Plastics

to be sure they're OK



these buyers did... A group of prospective lathe buyers witnessed an amazing demonstration of OK Bedway hardness at the Gisholt Machine Co., Madison, Wisconsin. Gisholt uses OK Ways exclusively on their ram and saddle turret lathes, and to prove the quality they (1) took a section from an OK Bedway, (2) made it into a tool bit, (3) locked it in a fixture and cut spiral shavings from 1045 cold-rolled steel.

look before you buy



here's why: OK Ways are so hard they're practically wear-proof, which helps maintain constant accuracy throughout the life of the machine. In Ohio Knife's exclusive manufacturing process, long-wearing tool steel is welded to a soft steel backing under 2500 tons pressure. Then the ultimate surface hardness of the special-analysis tool steel is developed with a special heat-treating technique that is far superior to simple flame-hardening, carburizing or induction-hardening methods. The result is extreme hardness, 65-66 Rockwell "C", uniform to 3/16" in depth.

For free Ohio Knife bulletin, showing seven standard cross-sections in over 60 sizes, write Dept. 31-B

THE OHIO KNIFE CO.

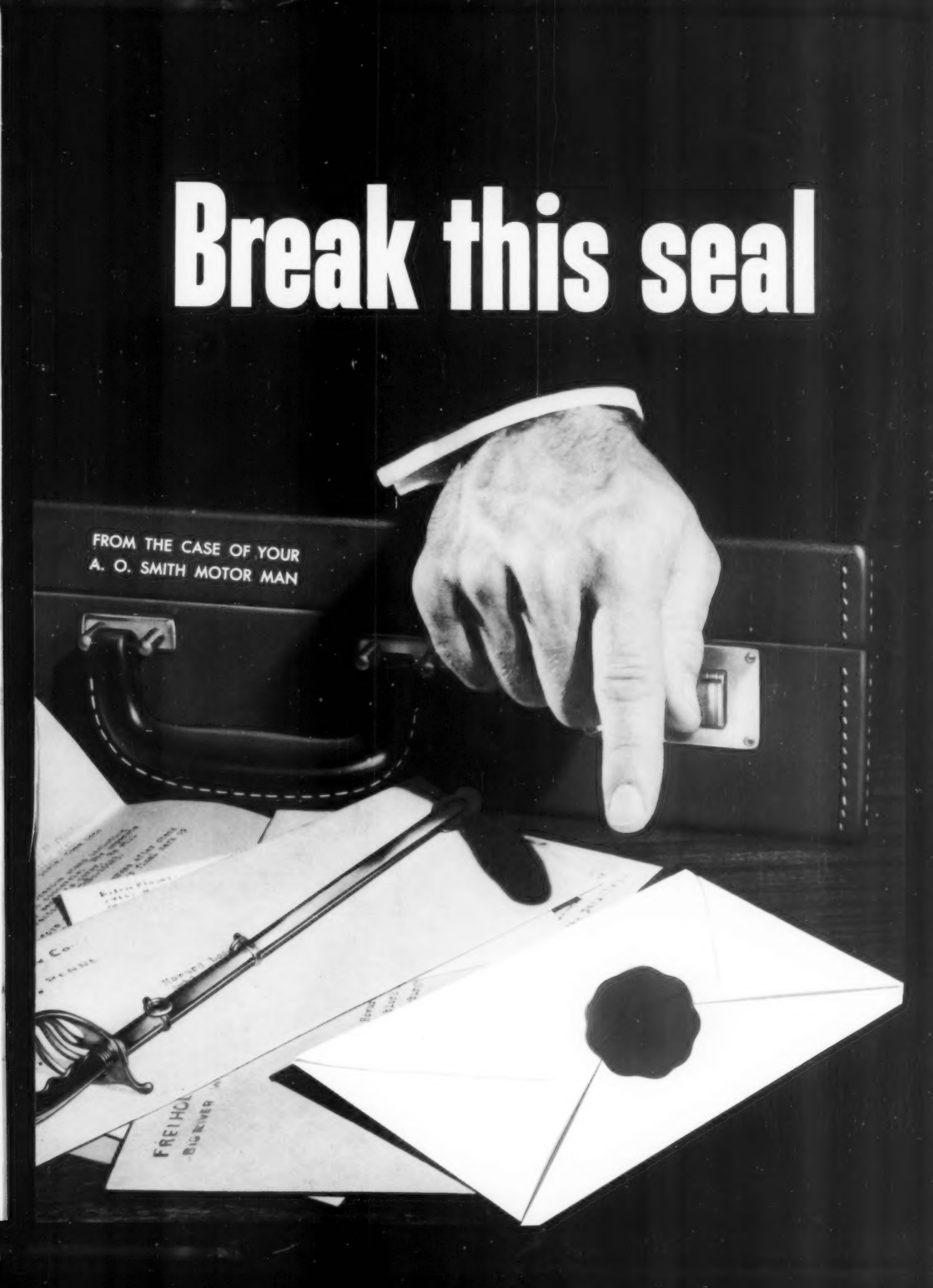
CINCINNATI 23, OHIO

SLITTER KNIVES • SHEAR BLADES • WORK-REST BLADES
CUT-OFF BLADES • HARDENED SPACERS • HARDENED WAYS
GIBS • BALL RACES • BRONZE WAYS • WEAR STRIPS

CIRCLE 110 READER SERVICE CARD

CIRCLE 111 READER SERVICE CARD→

Break this seal



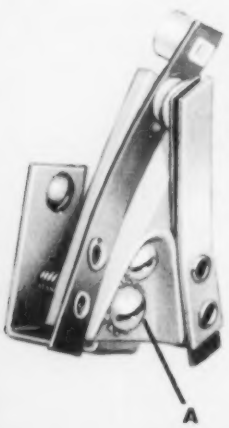
First major breakthrough in fractional hp motor design...

revolutionary new

...for switch, actuator, capacitor, thermostat and terminal board

1. Seals out dirt, lint, insects and other matter. Ventilating air *cannot* contaminate these vital parts.
2. Provides complete protection against mechanical damage.
3. Sealed capacitor and terminal board assures easy, all-position mounting. Absence of externally mounted capacitor* "dog house" and conduit box permits installation anywhere and in any position.
4. Bearings are prelubricated and sealed. Require *no* lubrication for the life of the motor.
5. Finally... ball bearing motors as quiet as sleeve bearing motors.
   - **A.** No more "book-end" bearings. New design permits much closer bearing centers.
   - **B.** Super-honed close tolerance bearings.
   - **C.** Magnetic noises reduced to absolute minimum by special machining and assembly processes.
   - **D.** Air noise practically eliminated through unique ventilation design.
6. Single phase motors with the new sealed starting switch are available from ½ to 5 hp. Included are specific designs for blowers, pumps, compressors, machine tools, and material handling equipment.

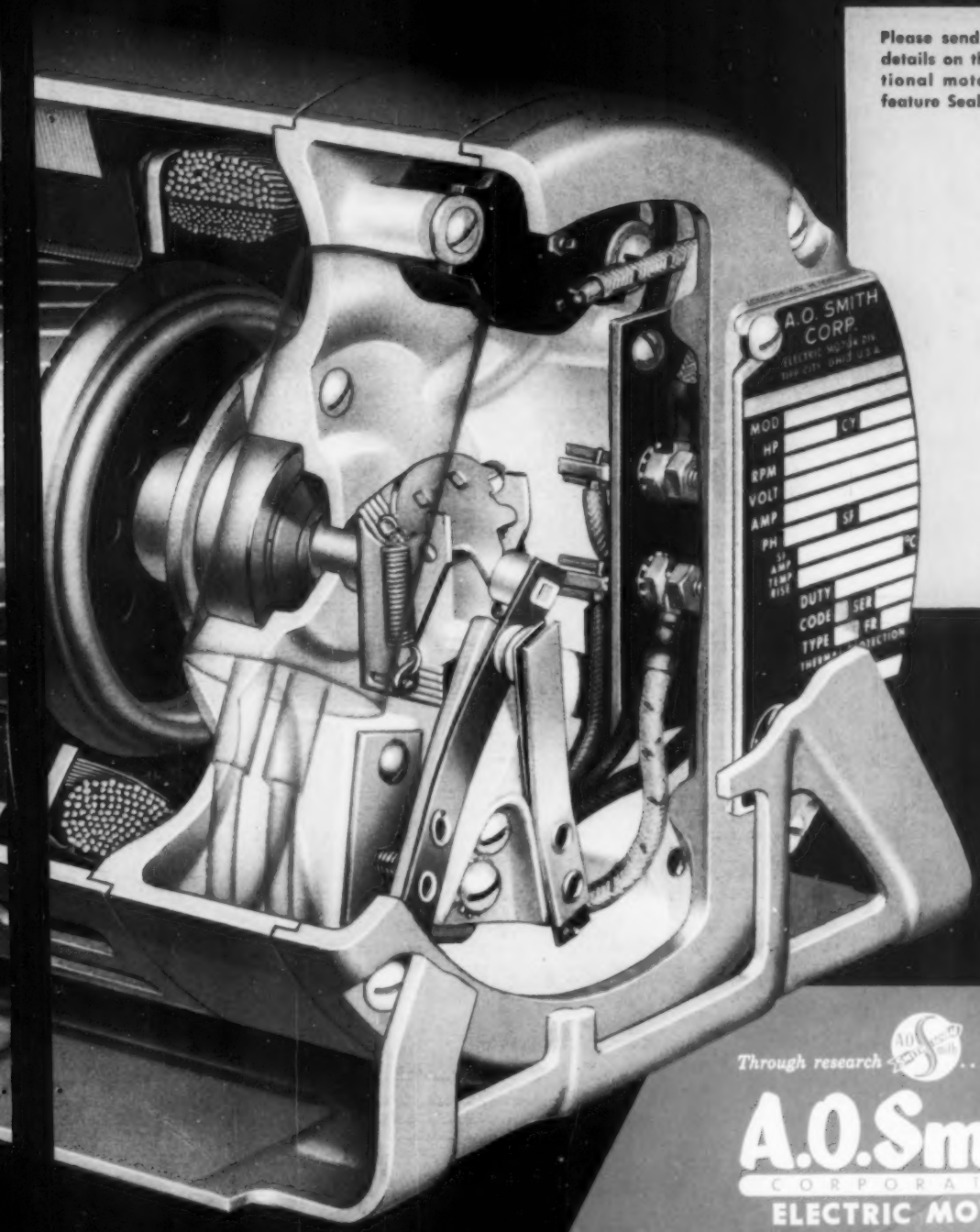
*Capacitor is internally mounted on motors rated 1 hp, 3600 rpm and 3/4 hp, 1800 rpm and smaller.



Adjustable starting switch

Every A. O. Smith single-phase motor features the new *exclusive* adjustable starting switch. The vital switching action is no longer dependent on a build-up of tolerances throughout the motor. On *every* motor the switch is adjusted *after assembly* by turning the self-locking screw (A) to achieve a preset clearance between the switch button and the actuator. This setting assures proper contact alignment and positive switching action... guaranteeing maximum life for every motor. Field adjustments and/or replacements are just as easy.

sealed capsule



Please send me more comprehensive details on the A. O. Smith line of fractional motors — ½ to 2 hp — that feature Sealed Capsule design.

NAME .....

FIRM .....

TITLE .....

ADDRESS .....

CITY ..... ZONE ..... STATE .....

Rigid or resilient base models available.

Through research ... *a better way*

A.O.Smith

CORPORATION

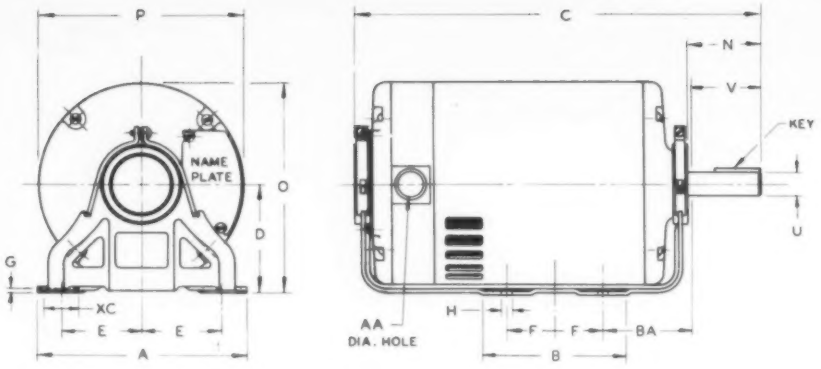
ELECTRIC MOTORS

531 North 4th Street

TIPP CITY, OHIO

NEW...
"SEALED CAPSULE"
FRACTIONALS

RIGID AND RESILIENT BASE



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ELECTRIC MOTORS
531 North 4th Street
TIPP CITY, OHIO

FIRST CLASS
PERMIT No. 83
Tipp City, Ohio

FRAME SIZE	DIMENSIONS IN INCHES										
	A	rigid B	resiliant B	C	D	E	F	G	H	N	O
56-1	6 1/2	4 3/4	4	11 3/16	3 1/2	2 7/16	1 1/2	5/32	11/32	1 15/16	6 11/16
56-2	6 1/2	4 3/4	4	12 3/16	3 1/2	2 7/16	1 1/2	5/32	11/32	1 15/16	6 11/16
56-3	6 1/2	4 3/4	4	12 11/16	3 1/2	2 7/16	1 1/2	5/32	11/32	1 15/16	6 11/16
56-4	6 1/2	4 3/4	4	13 3/16	3 1/2	2 7/16	1 1/2	5/32	11/32	1 15/16	6 11/16
56-5	6 1/2	4 3/4	4	14 7/16	3 1/2	2 7/16	1 1/2	5/32	11/32	2 5/16	6 11/16
56-6	6 1/2	4 3/4	4	15 1/16	3 1/2	2 7/16	1 1/2	5/32	11/32	2 5/16	6 11/16

FRAME SIZE	DIMENSIONS IN INCHES						
	P	U	V	AA	BA	XC	KEY
56-1	6 3/8	5/8	1 3/4	.859 .864	2 3/4	1 7/32	3/16 x 3/16 x 1 3/8
56-2	6 3/8	5/8	1 3/4	.859 .864	2 3/4	1 7/32	3/16 x 3/16 x 1 3/8
56-3	6 3/8	5/8	1 3/4	.859 .864	2 3/4	1 7/32	3/16 x 3/16 x 1 3/8
56-4	6 3/8	5/8	1 3/4	.859 .864	2 3/4	1 7/32	3/16 x 3/16 x 1 3/8
56-5	6 3/8	3/4	2 1/4	.859 .864	2 3/4	1 7/32	3/16 x 3/16 x 1 7/8
56-6	6 3/8	3/4	2 1/4	.859 .864	2 3/4	1 7/32	3/16 x 3/16 x 1 7/8

BLOWER MOTORS RESILIENT BASE

HORSEPOWER	1/3	1/3	1/2	1/2	3/4	3/4	1	1	1 1/2	2
R.P.M.	3600	1800	3600	1800	3600	1800	3600	1800	3600	3600
FRAME SIZE	56-1	56-1	56-1	56-2	56-2	56-3	56-3	56-5	56-5	56-6

GENERAL PURPOSE RIGID BASE

HORSEPOWER	1/3	1/3	1/2	1/2	3/4	3/4	1
R.P.M.	3600	1800	3600	1800	3600	1800	3600
FRAME SIZE	56-1	56-1	56-1	56-2	56-2	56-3	56-3

Through research ... a better way

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DEVELOPMENTS TO WATCH...

Design changes in pumps, valves . . .

. . . and metering equipment are foreshadowed by changes in aircraft fuels, civilian as well as military.

On the civilian side, there is the shift from aviation gas to turbo fuels. These have been in use by the military for some time, of course, but the change will pose new problems in the civilian field. As Esso's Aviation Department points out, jet aircraft require a lot more fuel than comparable piston engines—so fuel will have to be put aboard a lot faster if commercial schedules are to be met. Says Esso: a 4-engine piston plane takes on aviation gas at the rate of 600 gpm. A commercial jet will require delivery of its fuel at twice that rate—1200 gpm.

In the rocket and missile field, a change now being effected could have a major impact on equipment design: the development of such new oxidizers as fluorine and perchloryl fluoride. At the very least, they'll require somewhat different materials of construction than did liquid oxygen and nitrogen tetroxide—and there is hope that they will have greater stability. Bell Aircraft is working with liquid fluorine; Pennsalt with perchloryl fluoride.

Higher strength steels on a do-it-yourself basis . . .

. . . are promised by recent research in "warm-working" processes.

The steels announced by Ford Motor Co last month are one example of putting the new techniques to work. Ford has produced steels with tensile strengths as high as 400,000 psi, and good ductility—simply by controlling working temperature and heat treatment.

These strengths are achieved with relatively standard alloys; but even greater strengths may be possible by applying the new processing techniques to specially developed steels. Research in this area is already in progress in steel-company laboratories, and one leading steel producer, at least, is simply awaiting evidence of strong enough consumer interest before launching plans for commercial production.

Contact-free variable resistors, multi-pole relays . . .

. . . and highly efficient amplifiers, modulators and other signal-control components can be made by combining electroluminescent and photoconductive elements, says C. F. Spitzer of Lockheed's Missile Division. And, he adds, it should be possible to produce them at "negligible cost."

These devices, known as "lumistors," consist simply of an electroluminescent phosphor, the light emission of which can be controlled by the voltage applied to it (*PE*—Sep 15, p 74), and a solid-state photoconductor. Their basic simplicity and the availability of the materials used in their construction should, Spitzer believes, make it possible to produce and market such devices for about 2¢ a sq in., with an output rating of one watt per sq in. They might even be produced in sheet and tape form, backed with a pressure-sensitive adhesive.

On this basis, he believes, lumistor applications can range from computer elements to electronic clocks, with matrix switching systems and voltage-regulating mechanisms well within the range of possibilities.

Data on vibration-damping capacity . . .

. . . of magnesium and its alloys is coming from the Bureau of Mines Research Station at Rolla, Mo., to answer a long-felt need.

Using an improved testing technique, Bureau researchers find that cast, unalloyed magnesium has a much higher damping ability than highly alloyed metal. And, while specific chemical structure does not seem as important in determining damping ability as the rough percentage of additions involved, it has been found that silicon is more detrimental to damping effect than manganese or zirconium.

Also noted: those samples which showed the highest damping capacity developed their high performance at stresses of 1000 psi or less. Furthermore, increasing stress caused a continuing increase in damping capacity, at least to a stress level in the 3500-psi range.

On the basis of vibration-damping ability, Bureau researchers say, "Magnesium alloys can be selected to provide any reasonable degree (of performance) at an appropriate stress level." (For more news of magnesium, see Nov. 3, p 39.)

DEVELOPMENTS TO WATCH...

Standardized method for testing . . .

. . . . insulation resistance of printed-circuit boards is to be developed by a research group at the University of Delaware. Under joint sponsorship of EIA, NEMA, and ASTM, a research facility is being set up, should be in operation early next year. The objective, says Dr. James K. Davis, EIA representative on the Joint Steering Committee, is to develop "a standardized, reproducible method for testing surface resistance in printed wiring boards such as those used in radio and television receivers, computers, and advanced military electronic systems." Dimensional standards, already established, are available from EIA.

Photochemical storage batteries . . .

. . . that might permit more economical use of solar energy are being developed at Polytechnic Institute of Brooklyn under Air Force sponsorship. While Dr. Gerald Oster, who is in charge of the project, emphasizes research is still in its very early stages, compounds have been found which will change their form, absorbing energy when exposed to light, then change back again when the light source is removed.

Certain dyes, for instance, in the presence of a suitable reducing agent, can convert as much as 25% of the energy they receive into "chemical products which, if used as one chamber of an electrical cell, would produce electricity." The amount of energy absorbed during the light reaction and set free by the dark reaction is on the order of 1.2 to 1.4 volts. (For more on new batteries, see *PE*—May 12, p. 72.)

Internal splines can be swaged . . .

. . . on a new machine being introduced by the Meta-Dynamics Div of Cincinnati Milling. The machine, called *Intraform*, literally squeezes hollow stock over a mandrel. It uses a set of 4 rapidly pulsating forming dies actuated by cams working against free-wheeling hardened-steel rollers.

One of many new developments in "chipless machining," the machine is said to produce profiles on the ID of cylindrical workpieces without waste of material, and to do the job quickly and accurately with relatively inexpensive tooling.

The machine can handle pieces up to 5 in. dia, of ferrous and nonferrous metals, in the form of tubing, castings, forgings, extrusions, or powder-metallurgy parts, and can hold size limits as close as 0.0002 in. Expected applications range from rifle barrels to heat-exchanger tubing.

(For design information, see coming Dec. 8 issue.)

Parts can be built from ultrahard metals . . .

. . . by taking advantage of the plasma arc processes now becoming available commercially (*PE*—Aug 25, p 5). Linde Co, one of those pioneering in the field, says the process can not only be used to coat parts with such metals as tantalum and tungsten, but also to build parts completely of these metals. It may also find application in such "everyday" work as plating aluminum with stainless steel.

Capacitors for the 900-F range . . .

. . . can be made by combining successive layers of platinum and such dielectric materials as alumina and boron nitride, says A. L. Berg of Servomechanisms Inc. Reporting on an Air Force-sponsored research project, he says techniques have been worked out for depositing the dielectric materials as well as the platinum by vacuum thermal evaporation, and capacitors can be made in either flat or tubular form by both methods.

A progress report on the study, which includes data on magnesia, zirconia, and other dielectrics, as well as the two mentioned above, may be obtained from OTS (PB 131848, 90 pages, $2.25).

Also being developed under Air Force sponsorship are barium-titanate capacitors, these for temperatures from −100 to 500 F. According to Horizons Inc, which is doing this work, capacitors made of a combination of barium titanate (80%), lead titanate (17%) and tantalum oxide (3%) can stand 1000 hr at 1000 v; show insulation resistance up to 6 megohm microfarads at 500 F, and more than 50 megohm microfarads at 400 F. —ARG

Red China Joins USSR to Pioneer New Automation Techniques

Even though the USSR and China are teeming with population; it is largely unskilled, so the two nations are laying great emphasis on computer control. They are searching for new technologies to enlarge computer capability. And they are weaving computers into the texture of the industrial structure. Some of these practical applications and some of the new technologies that may open the way to more comprehensive or precise computer applications are analyzed by our London correspondent, Peter Trippe.

LONDON—Computer control as practiced today may soon become old hat through the efforts of Soviet engineers and Chinese production planners.

Such obsolescence is foreshadowed by several projects now under development in the USSR. These include:

- Mass control of machines with a single programming tape.
- Adaptation of pneumatic gaging for "pneumatic computers" that are capable of performing the machine-control functions of the electronic computer, but at far less cost.
- Employment of bio-currents to reproduce remotely the movements of a machine operator.

Practical application of computers in China stems from her leaders' drive to build a major industrial nation with the labor of 600,000,000 unskilled workers. Chinese universities are cooperating with machine-tool plants and government to forge a concept of numerical control that is unparalleled in the West. Some university projects have been described in recent government reports. They include:

- Tientsin Univ has built a prototype programmed lathe with magnetic tape control. This feat was accomplished by 8 teachers and 45 students.
- Tsinghua Univ, cooperating with Peiping No. 1 Machine Tool Plant, has produced a vertical milling machine with computer control. The machine is said to have been built in less than three months by students whose average age was less than 24.

If Chinese claims are true—and there seems little reason to doubt them—university students are building machines appreciably faster than we in the West even with our production resources.

Chinese sources have said they believe they can make the vast quantities of products they need by application of numerical control. They envision a single master tape with a control program directing scores of lathes that operate simultaneously. Such a concept could conceivably swamp the world with products whose production costs include almost nothing for skilled manpower. As a goal, it contrasts vividly with the isolated applications that Western countries are making of numerically controlled machines.

RUSSIA'S TECHNICAL ADVANCES

Russia's compressed-air computer has been developed at the Institute of Automatics and Telemechanics of the Academy of Science. This machine adds, subtracts, multiplies and divides, solves second-degree problems and problems in higher mathematics. In design, the pneumatic computer includes a small bronze cube connected by rubber tubes to the control unit. The control unit has four gages and associated control handles. Within the bronze cube are a series of metal diaphragms each enclosing a chamber of rubberized cloth sections.

Problems are fed to the cube by adjusting air pressure applied from three of the sources on the control panel and adjusting associated hand-wheels until the dials give the appropriate reading. These adjustments control air pressure applied to the fourth dial through interaction of metal chambers in the cube. Hence, the fourth dial answers problems fed to it by the other three.

Though not as fast as an electronic computer, the pneumatic version is fast enough for machine programming control and is said to have an accuracy to 0.35%. Its designers hope to make units of plastic and plug them into program arrangements.

Remote-control bio-currents (*PE—Nov. 10, p 39*) sound like a blend of H. G. Wells and science fiction. Developed by the Research Institute of the Prosthetics Manufacture and Design, and the Machinery Study Institute of the Academy of Science, the bio-arm is based on knowledge that muscular movement produces minute electrical currents and that muscular activity can be induced by discharging a current through the cells. Eventually the Soviets hope to produce an arm that will feel things.

Noncomputer applications are seen in remote control of "hot" radioactive processes for more precise handling

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Cast urethane rubber . . .
has found an opening in its quest for a market in the aircraft industry. Though urethane is a premium product, Douglas Aircraft has advised the Navy to switch to this material for tail wheels on the F4D-1 because of its unusual abrasion resistance. In abrasion trials, an experimental tire made by Disogrin Industries Inc showed no damage until after 58 touch-and-go landings, where the craft hits ground and takes off without coming to a full stop; and 33 arrested landings, where the craft drags to a stop. This, Douglas says, is performance considerably superior to that of black rubber compound on present wheels, and should lead to reduced maintenance costs. Tail wheels of the F4D-1 are subjected to severe tensile stresses during field landings because the pilot keeps the nose of the craft high to take advantage of aerodynamic breaking and skids the tail to reduce impact load.

than is possible with present servo-controlled automatic hands. Another portentous application is in manned satellites. Pilots could wear bracelets and helmets that pick up and transmit an electrical impulse to bio-electrical instruments when the pilot adjusts controls. His decisions could be applied more rapidly than when he depends on human reaction. Bio-controls have also been considered as possible control apparatus for dosing anesthetics in surgical operations or in picking up currents of lung muscles to automatically control oxygen apparatus.

APPLIES TO CYBERNETICS

In cybernetics, bio-electrical controls are of considerable interest. Such controls could alter methods of feeding information into and out of computers and between machines. And they could provide for tool selection and changes in programmed single-spindle programmed machining where motion sequences are difficult to produce with normal mechanical devices. Conceivably, too, they could open new horizons in automatic assembly.

GREAT AMBITIONS

Applications of new technologies to computers are speculative. But the Soviets have marshalled a number of feats that testify to their interest and ambitions in cybernetics. These include the much publicized "automatic-engine driver" (*PE—Oct 6, p 16*) and a computer for controlling railway cars at marshalling yards. The Soviets are also using rapid-acting computers to eliminate losses when cutting rolled metal, by determining optimum lengths in advance and making allowances for cutting tolerances. In electric arc furnaces, a computing device now maintains predetermined average current when melting high-quality steel. This device was tested last year at Elektrostal Mill and is said to control to within 1.5 or 2%. Also, a lattice-type computer system with electronic programming and automatic devices is operating at the USSR Oil and Gas Research Institute. This system has solved problems in subterranean hydraulics, making it possible to reduce the number of wells that had to be sunk by 40 to 50% at a saving of a million rubles per well.

Industrial Designer Calls for Do-it-yourself Market Research

Los Angeles—The industrial designer must "saturate himself" with his own informal market research and then let it help guide his product planning, Henry Dreyfuss told the Research and the Engineering Consultants and Architects Committees here.

Good design is not enough by itself, said this noted leader in the field. The designer must make certain that the public will accept the product when it reaches the market. This also explains, Dreyfuss said, why a formal market research survey, which gives an exact picture of the existing market, is inadequate too—as much as 10 years may elapse between design of a product and its tooling, production and distribution.

The designer, Dreyfuss emphasized, must keep himself informed of current events, trends, styles and technology; and learn to project these trends into his designs. Formal research surveys are a check to prevent him from moving too far ahead of the public.

The speaker said formal research resembled the processing of clues and information on a crime by Scotland Yard and he likened the "educated hunch" of the good industrial designer to the Sherlock Holmes deduction.

Some suggestions he makes for his own people, Dreyfuss said, are: to visit each department in a department store monthly, choosing a different class store on each go-around; to scan several good newspapers; and to read the magazines read by those who will buy the products—though the magazines be Seventeen or Hot Rodder.

Dreyfuss described scornfully the railroad whose executives never ride coaches, and the executive who asked an "intimidated" secretary to evaluate a product or who took it home for a "family vote of confidence."

The Dreyfuss organization, he said, often creates working models that exactly duplicate the product in size, finish, exterior detail and major working characteristics. In designing staterooms for the ocean liners Independence and Constitution, he noted, his firm built eight full-scale models and hired people from passenger lists to move in and hang up their clothes. This experiment showed, among other discoveries, that closet poles should be raised a few inches above standard height to make space for evening dresses. Design modification, he said, was easy; correcting bad design would have been expensive.

Case Plans Research Guide

Cleveland—A manual with a mathematical formula to guide firms in deciding how much money to put into research and in what projects to put it for maximum profits is being prepared by Case Institute for the National Science Foundation. The manual is expected sometime in 1959.

Second phase of the long-term project, case sources say, will extend findings for individual firms to an entire industry. Chemicals is the first industry on the list. Third stage is extension of the formula to the entire economy to show how money spent affects profits of other industries.

This rings a bell . . .
in the success story of Henry Dreyfuss. It's the modern telephone, one of his favorite design subjects—and example of his blending research and hunch methods to turn out a practical product the consumer is eager to have. Dreyfuss employed eye specialists to check visibility of the dial because he knew faster dialing would add up to more calls going through existing facilities.

Earthmovers still get larger . . .
A scraper roughly double the size of the one shown recently (PE. Sept 1, p. 23), has been announced by R G LeTourneau, Inc, Longview, Tex. The new self-loader is more than 100 ft long, has a 130-ton capacity, and controlled by one operator. The two buckets can load and discharge separately. Propulsion is designed around the "electric wheel" developed by LeTourneau. Two 600-hp diesels drive ac and dc generators which furnish power for the dc motors geared to all eight wheels, and ac auxiliaries.

Checker's Superba to Bow in January

KALAMAZOO, MICH.—The Checker Motor Corp has announced it will put its new Superba passenger car on the market in January. The company will hold press previews next month.

Though design details have not yet been released, company sources say the Superba will be "practical" and will emphasize "passenger comfort." It is said to be shorter than today's conventional cars, yet have more seating space.

Superba also is expected to depart from the Detroit tradition of rapid obsolescence. Not an economy car, it will presumably be priced in the middle or upper range, but be designed for long life. It is thought that power brakes, steering, and automatic transmission will be available.

Checker Motors expects to turn out Superba at the rate of 100 a day on the same equipment used for its Checker Cabs. The company will make its own stampings for the car and assemble its own frames. Only a few components such as crossmembers will be purchased outside. The new car will have a Continental engine redesigned to Checker specifications.

Seek Engine to Power Heavier Satellite

WASHINGTON—The Defense Dept has contracted for design of a rocket engine which will put a satellite of several thousand pounds into orbit. The award is for design and development of a liquid fuel, upper-stage rocket to be used in conjunction with an Atlas-type launcher. The contract went to the Pratt and Whitney Div. of United Aircraft Corp., and provides about $9 million for initial expenditure on the design project. Cost of the complete development program is estimated about $23 million.

Announcement by the Air Force research and development command said that "Use of such a high-energy upper stage in conjunction with an Atlas-type first stage vehicle would permit placing into orbit a satellite weighing several thousand pounds." The announcement did not specify power of the rocket. It is understood the Air Force wants an engine with a thrust of between 20,000 and 50,000 lb. This would be well in excess of upper-stage rocket engines used for present satellite and lunar probe vehicles.

Sabrejet Trainer . . .
North American's Sabreliner is powered by two GE J-85 engines, can carry 10 persons, has top speed of 575 mph. The trainer is 43 ft long, has a 42-ft wing span, gross takeoff weight of 15,320 lb, and will cruise at 39,000 ft. Observers say the Air Force has contracted with NAA for 10 Sabreliners by 1960 at a cost of $14 million, the engines costing more than $100,000 each. NAA was only aircraft firm to follow through of several that originally expressed interest.

Industries Review R&D Spending

ATLANTIC CITY—American industry spent $8 billion for research this year and will spend $9 billion by 1960, C H Bartlett, vice-president of Westinghouse Electric, told the National Electrical Manufacturers Association.

The electrical manufacturing industry itself is turning 6% of its sales income into R & D—either in its own labs or on contract projects—he said. This accounts for about ⅓ of all industrial R & D today.

Mr. Bartlett sees a tremendous backlog of new principles, theories, products and processes to benefit the economy over the next 20 years. These are certain to come, he says, unless the electrical industry reacts to short-range economic problems by retrenching on engineering and development programs, or fails to adequately sell and promote the use of power.

WASHINGTON—In 1956, private industry spent $2 billion on applied R & D for aircraft and missiles, the Aircraft Industries Association reports. This accounts for about 30% of the $6.2 billion spent on industrial R & D that year.

Aircraft firms, the AIA notes, accounted for $1.6 billion of the aircraft and missile development funds. The electrical equipment industry ranks second with $147 million.

It's all aluminum . . .
Reported by Canadian National Railways as the first all-aluminum railway refrigerator car, this vehicle is 22% lighter than previous models, representing a 7-ton weight reduction. Only the heater, door, hatch hardware, and certain safety equipment are not aluminum. Repairs and repainting caused by corrosion of the brine solution used in the refrigerator equipment are virtually eliminated, CNR says. The roof, side sheets and ends of the car have been left unpainted.

US Product Planners Score Against International Design Pirates

WASHINGTON—American industrial designers have chalked up an important victory in their battle for greater world-wide protection against design piracy. The step forward will spur their fight for a new law from Congress aimed at wiping out the evil at home.

The victory was achieved at the 40-nation diplomatic conference for the revision of the international convention for the protection of industrial properties which met at Lisbon Oct 6 to 31. It came in the form of an unprecedented move by the intergovernmental organization requiring that all member countries grant patent protection for industrial design.

The new provision—adopted unanimously—means that any present signatory to the convention that has not already done so must provide patent protection for industrial design under its own national law. Future members—and there were observers from 11 nonmember governments at the Lisbon meeting—must comply with this rule.

The Lisbon meeting rejected several proposed changes spelling out detailed standards of patent protection that each member country must provide for design patents. These covered such matters as the period of patent protection allowed, the types of products protected, etc.

SEEK WORLD-WIDE CODE

Main reason for this action is the recent agreement of the two rival world-wide governmental copyright organizations to launch a joint study looking toward drafting a uniform international code to provide simplified, more effective protection in their field. In many countries outside the US, industrial and commercial designs are subject to overlapping coverage by copyright as well as patent and trademark statutes, so the prospective study will bear down heavily on design protection.

The Lisbon patent group—popularly known as the Union for the Protection of Industrial Property—last month accepted an invitation from the two copyright organizations to join in their study. The result could be an entirely new and separate international agreement devoted exclusively to protecting private ownership rights in the burgeoning field of industrial design.

Soon after Congress convenes, the major US design organizations will be pressing for hearings on their proposal for a radically new system to fight design piracy and similar evils. Their method—embodied in legislation introduced by Rep. Edwin E. Willis, (Dem, La.)—is to create a new agency to administer a new system of patent protection for industrial design.

Under the bill, a designer could circumvent the patent office and its time-consuming procedures by simply depositing his new design at the new agency. This would automatically and immediately confirm five-year protection for the design. If the design is put to commercial use in that period, the owner can get a five-year renewal. If no commercial application is made, he loses his protection. As designers supporting the Willis bill see it, a speedy and relatively short protection system is the only practical answer to design piracy. A House judiciary subcommittee, is expected to hold hearings next year. Prospects for enactment are bright.

British Go Italian in Car Styling

LONDON—Emphasis was strictly on appearance, with technical innovation virtually absent at the recent British International Motor Show here, according to John Tunstall, PRODUCT ENGINEERING's London field editor. There was more Italian body styling, but only a few entirely new models—mostly in the high-price bracket.

Emphasis on appearance stems from two factors—its importance in export markets, and growing awareness of the feminine influence in car purchasing. British manufacturers are preparing an intensified sales effort on the Continent and have exhorted Italian designers to outdo each other in the restyling of popular existing British models. Strictly British design characteristics are likely to be relegated to the doghouse for some time to come.

Examples of the Italian influence are: the Austin A40 featuring a rear overhung roof styled by Farina; the new lines of the revised Mark 3 Vanguard by Michelotti; and the new Aston Martin DB4 by Touring.

MECHANICAL INNOVATIONS

There were more 4-wheel disk brake applications, but mostly for high-performance sports cars. There were no cars with air suspensions, although such systems were on display. The only direct fuel injection was found on the German Mercedes-Benz.

Power steering—is still optional on only a few of the high-price cars, and the automatic transmission has made little inroad on the British preference for manual gear shifting. In fact, the trend of the gear shift lever is back to the floor.

Engine—changes were as scarce as the new models, and gas turbines had vanished. Of interest was the Perkings 1.6-litre diesel engine designed for installation in several popular medium-price cars. A simple and cheap oil-level indicator was shown as a replacement for the dip stick.

A new family of electric dashboard instruments—thermometer, fuel and oil-pressure gage—working on the bimetal principal were featured.

Bids Asked on Space Capsule Design

LANGLEY FIELD, VA.—The Langley Research Center of the National Aeronautics and Space Administration hosted 38 representatives of 38 missile and aviation manufacturers for a discussion of preliminary specifications for the design of a space flight capsule for research purposes. Bids were invited for the long-term development program. NASA, who is working with the Advanced Research Projects Agency of the Dept. of Defense on the project, expects to award a contract for the space vehicle sometime after the first of the year.

COMING EVENTS

NOVEMBER

25 . . . . Manufacturing Chemists Association, 8th Semi-annual Meeting and Winter Conference, Hotel Statler, New York.

28-Dec 4 . . . . Radio Communication & Electronic Engineering Association and Office Appliance & Business Equipment Trades Association, 1st Electronic Computer Exhibition, London, England.

30-Dec 5 . . . . American Association Mechanical Engineers, Annual Meeting, Statler & Sheraton McAlpin Hotels, N. Y.

DECEMBER

1-5 . . . . American Society of Mechanical Engineers, 23rd National Exposition of Power and Mechanical Engineering.

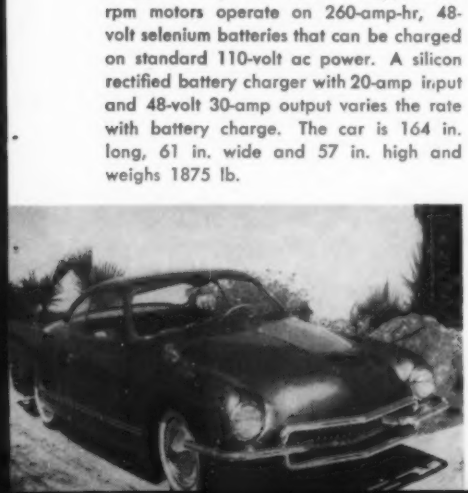
2-4 . . . . Electronic Industries Association, Third Conference on Reliable Electrical Connections, Statler-Hilton Hotel, Dallas, Texas.

3-5 . . . . American Institute of Electrical Engineers, Institute of Radio Engineers Association for Computing Machinery, 1958 Joint Computer Conference, Bellevue-Stratford Hotel, Philadelphia, Penna.

3-5 . . . . Institute of Radio Engineers, American Institute of Electrical Engineers, Second National Symposium on Global Communications, Colonial Inn & Desert Ranch, St. Petersburg, Fla.

8-10 . . . . American Nuclear Society Meeting, Sheraton-Cadillac Hotel, Detroit, Mich.

An electric passenger car . . .
with speeds up to 60 mph and range of 80 mi is scheduled for production in the San Diego area in April 1959. Dubbed the Charles Town-About and manufactured by Stinson Tool and Engineering Corp, the vehicle is designed for urban driving. Its two 2½-hp, 2700-rpm motors operate on 260-amp-hr, 48-volt selenium batteries that can be charged on standard 110-volt ac power. A silicon rectified battery charger with 20-amp input and 48-volt 30-amp output varies the rate with battery charge. The car is 164 in. long, 61 in. wide and 57 in. high and weighs 1875 lb.



World Getting Together on Standardized Testing

WASHINGTON—Considerable progress has been made toward obtaining uniform international testing methods. The 12-year-old International Standardization Organization's Technical Committee 61 on Plastics held a week-long working session here recently and hammered out an impressive draft of recommendations and proposals that will now go to member nations for a vote.

Comprising some 92 technical committees, the ISO has so far won agreement among nations on some 25 to 30 test procedures. Dozens of other proposals, however, are in various stages of completion.

Some 56 delegates from 12 countries, including the USSR, met as Technical Committee 61; then split up into eight working groups. A total of 14 sessions were held and 35 different proposals were considered.

Here are the main results reported:

1. **Nomenclature and equivalent terms**—Agreement on a list of 780 equivalent terms. The purpose is to get international uniformity for terminology used in the plastics industry. The list will now be printed in the three official languages of ISO—English, French and Russian—and sent to member nations for vote.

2. **Mechanical strength properties**—Agreement that ASTM standard D 638-56, "Tensile Properties of Plastics," become an ISO recommendation. A majority of nations must now adopt this before it can become an ISO standard.

The group made the same recommendation for S. P. 174, "The Testing of Plastics with the Torsion Pendulum." And Working Group II recommended to the ISO secretariat that members of the plastics technical committee be appointed to act as observers with the metals technical committee "to promote the use of the same or equivalent terms and definitions for specimens and methods in testing metals and plastics."

3. **Conditioning**—Approval on standard atmospheres for conditioning and testing plastic materials. Working Group III also requested that the ISO prepare a document on methods of measurement and control of relative humidity in large and small enclosures.

4. **Thermal properties** — Recommended that the task group on flow properties of thermoplastics consider extending this test method to high density polyethylenes of low melt flow index. The Vicat softening point test method was adopted to be put to member nations of the plastics technical committee for consideration.

5. **Physical-chemical properties**—Two proposals include: determination of the viscosity number of polyamide resins in solutions, and determination of acetone soluble matter of phenolic molding materials.

6. **Aging, chemical and environmental resistance**—Agreed to hold a meeting of microbiological and plastics specialists early next year in Prague for the purpose of laying the foundation for a draft proposal to be made at next year's technical committee meeting.

Further investigation was decided on by the group on the determination of thermal stability of polyvinyl chloride and related copolymers and their compounds by discoloration. Further study was also ordered for a test method to determine the change in mechanical properties after contact with chemical substances. More work must also be done by this working group on such matters as environmental stress-cracking, weathering resistance in both artificial and natural conditions, and resistance to attack by chemicals in the soil.

7. **Preparation of test specimens**—Three testing methods were approved by the group and sent to the general secretariat as ISO recommendations. First methods are recommended practice for compression-molding test specimens of thermoplastic and thermosetting materials, and injection-molding test specimens of thermoplastic materials.

8. **Electrical properties**—Agreed to submit to other members of the plastics technical committee as a draft proposal a method of test for tracking under moist conditions. No action

was taken on a method of measuring electrolytic corrosion of copper. A proposed method for determining homogeneity by measurement of volume resistivity was tabled for further consideration.

Next year's ISO meeting will be in Munich on October 26-31.

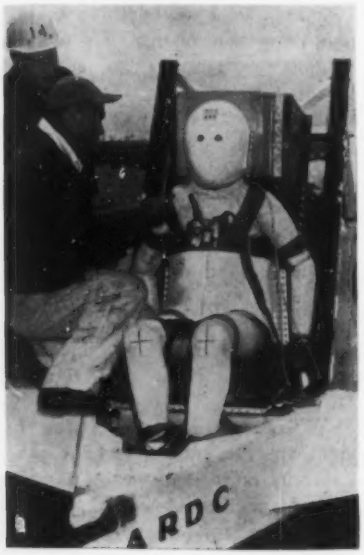
Dummy Endures 4000-psf Windblast

McGREGOR, TEXAS—A life-size dummy strapped in a special high-speed test sled and propelled by a large solid-propellant rocket engine, has survived a wind blast of 4000 lb per sq ft at the Air Force Missile Development Center, Holloman AFB, New Mexico.

The dummy, wearing new-type pilot-protection suit shown below, survived a 35,000-ft test run at speeds in excess of 1200 mph. This special one-piece suit is actually two separate garments. Outside is white dacron sailcloth; inner garment consists of three layers—wool, aluminized dacron (which reflects the heat energy generated under conditions of windblast) and cotton.

A fiberglass helmet encloses the entire head and face to prevent damage from windblast heat radiation. Two small ½-in. circles at eye level were the only openings.

Test sled with its 2000-lb payload is boosted to 1200 mph in less than 8 sec by an Astrodyne rocket. Charge is extruded ammonium nitrate.

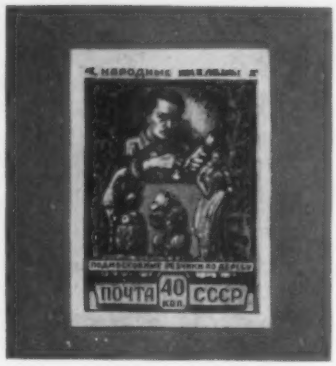


READER TO EDITOR

Stamp Propaganda

To the Editor:

This picture of stamps on a recent letter I received from Moscow will recall the East German worker's lament about Sputniks ("Reader to Editor," Oct 20, p 4). The gaily colored originals show the



crossed-out A-bomb more clearly than do two photographic copies.

I understand that the larger stamps refer to a village (?) near Moscow noted for its wood carvings: the craftsman and his products are shown. —R S HARTENBERG
Professor, Mechanical Engineering
Northwestern University

Wet Motors

To the Editor:

I read with interest the article on open-construction wet motors using polyethylene insulation (Sept 15, p 80). You might be interested to know that open-construction wet motors using polyvinylchloride were in use in 1943 in England (Hayward-Tyler). Westinghouse Electric Corp is now building P.V.C. motors in this country. —A. J. PORWIT
Edward Valves Inc
East Chicago, Ind.

Russian Publications

To the Editor:

In several of your recent issues you have mentioned material which has been published in Russian technical publications. Are these publications hard to acquire and are they all in Russian?

—DR MAX KRONENBERG
Cincinnati

• Most Russian publications can be obtained quite easily in this country. The only drawback is that they are in Russian. Russia does have some magazines for the American market such as: *Moscow News*, *Soviet Union* and *Friendship*. However, these are exactly what you would expect them to be. The technical publications, of which there are a great many, include such magazines as: *Rocketry*, *Atomic Energy*, *Mechanical Engineering*, *Mathematical Symposium*; also booklets on machine building, which include, machine design, equipment and foundry production, measuring, technics and automatics, and a host of others. For a catalog of Russian magazines and publications contact: Four Continent Book Corp., 822 Broadway, New York 3. —Ed.

Typewriter for Large Drawings

To the Editor:

With reference to "Why Don't They Research and Develop" in the Oct 20 issue, p 38, it is suggested that a portable typewriter be developed to type on large engineering drawings.

The Vari-Typer Corporation, 310 South 69th St, Upper Darby, Penna., (near Philadelphia) produces a machine which is not portable but will type on any size drawings. We have one in use at our North Wales, Penna., plant. —WM P WEST
Leeds & Northrop Co
Philadelphia, Penna.

A Dog-gone Mouse

To the Editor:

Travel delayed my reading your editorial of August 18th. It is constructive to be reassuring. However, to omit any reference to what achieving a greater payload means in rocketry is to mislead the people unintentionally. —B B SABOUNI
Director of Research
Soulé Steel Co, San Francisco

• The editorial in question, "A Dog-gone Mouse", may have left the unintended impression that the size of the payload in the orbiting vehicles was of no importance. This is obviously not true, as indicated by current newspaper reports which suggest that our first man-carrying rocket to outer space can carry as a passenger only a lightweight doctor. (A physician is suggested because he presumably would know more about his own reactions and should be better able to take care of himself in those confined conditions.) The top weight of 150 lb is dictated by the carrying capacity of the rockets we will presumably be able to produce by that time. Obviously the Russians are not limited to a lightweight doctor even now. —EJT

We Slipped

In "How to Figure Deflections of Elastically Supported Cantilever Beams," Aug 4, in the formulas on p. 63, for "b" read *l*. On p. 64, cases 3, 5 and 7, "$b = b$" should read $b = l$. Thus in the equation for D_1 the term in the first bracket will be $(21^3 - 3al^2 + a^3)$

THE ONLY LINE OF

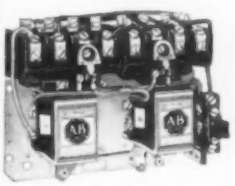
D. C.
MOTOR STARTERS
with modern
SOLENOID CONTACTORS

With Allen-Bradley, you get D. C. motor control that is *completely modern!* It uses the simplest switching mechanism yet conceived . . . the solenoid contactor with only ONE moving part. There are no bearings to stick . . . no jumpers to break. This assures millions of trouble free operations. And the double break, silver alloy contacts never need maintenance. Available in ratings up through Size 4. Write for details.

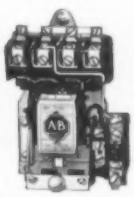
CONTACTORS

Bulletin 202 solenoid type contactor. In ratings to 150 amp. Also, clapper type to 600 amperes.

FULL VOLTAGE STARTERS

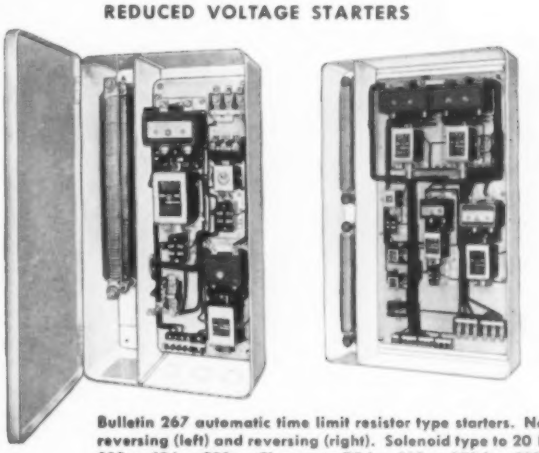


Bulletin 205 full voltage reversing starter. Ratings to 1½ hp, 115 v; 2 hp, 230 v.



Bulletin 209 full voltage starter. Available in ratings up to 1½ hp, 115 v; 2 hp, 230 v.

REDUCED VOLTAGE STARTERS



Bulletin 267 automatic time limit resistor type starters. Non-reversing (left) and reversing (right). Solenoid type to 20 hp, 115 v; 40 hp, 230 v. Clapper to 75 hp, 115 v; 150 hp, 230 v.

11-58-MR

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

MAIN OFFICE and Factory
1316 S. Second St.
Milwaukee 4, Wis.

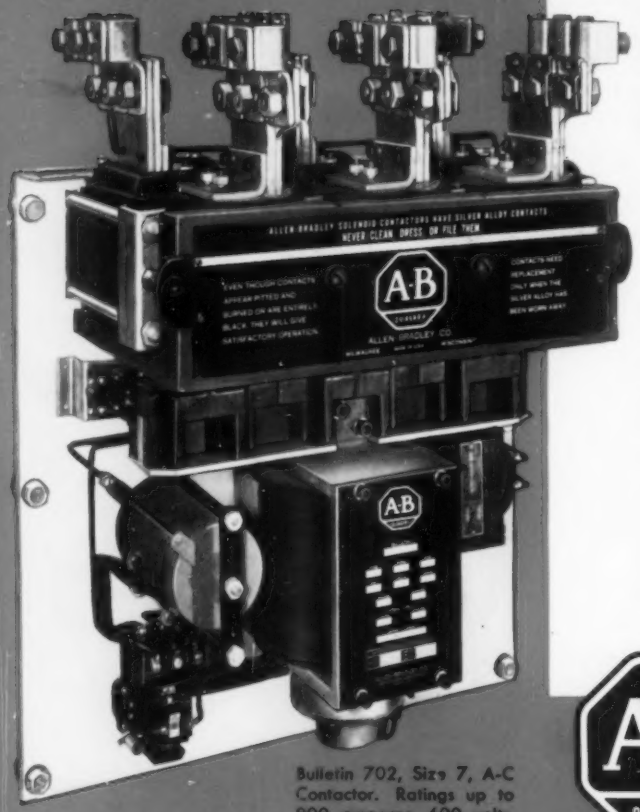
In Canada: Allen-Bradley Canada Ltd., Galt, Ontario

only

ALLEN-BRADLEY gives you Trouble Free Solenoid Starters in ALL SIZES!

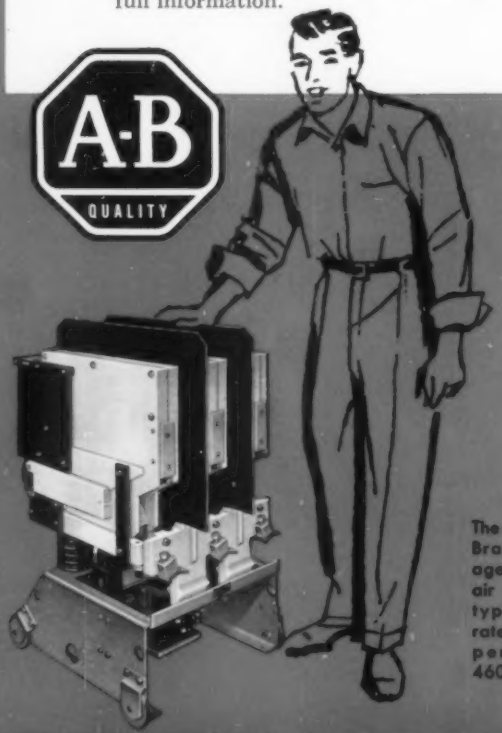
The simple solenoid design—exclusive with Allen-Bradley in the big starter sizes—has only one moving part. This eliminates the trouble causing bearings and flexible jumpers of conventional clapper switches . . . and assures millions of trouble free operations. A-B solenoid starters also have double break, silver alloy contacts that never need any servicing. They are always in perfect operating condition—until the contact is completely used up.

This time-tested solenoid construction is available on *all* Allen-Bradley starters up through Size 7 . . . as well as on A-B's rugged, air break, high voltage starters. Write for full information.

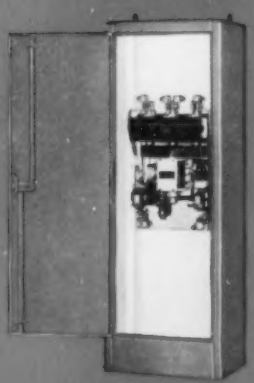


Bulletin 702, Size 7, A-C Contactor. Ratings up to 900 amperes, 600 volts. This basic solenoid contactor is used in large A-B low voltage starters.

A-B QUALITY



The heart of Allen-Bradley high voltage starters is this air break, solenoid type contactor—rated at 400 amperes, 2300 or 4600 volts.



Bulletin 709 across-the-line solenoid starters are made in ratings to 300 hp, 220 v; 600 hp, 440-550 v.

A-B high voltage starters are built for all types of motors. Ratings to 1500 hp, 2300 v; 2500 hp, 4600 v.

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

11-58-MR

Getting more service hours per dollar

HOW TO SPECIFY FLEXIBLE METAL HOSE

3 simple steps can help you select metal hose for best results and longer service life

The important job of selecting the *most economical*, the *one right* flexible metal hose for your product or transfer problem can be greatly simplified by following these 3 steps:

1 Send exact specifications

Complete and exact statement of operating conditions will go far in saving you money on flexible metal hose.

First, it assures you that the connector you get will live up to your expectations. And, second, that manufacturers won't bid on hose that's "over-engineered." You'll save in the long run because you'll get the right assembly for every job.

Here is the information we need before we can give you our best suggestions:

A PHYSICAL REQUIREMENTS:

1) *Over-all length (including fittings)*
2) *Diameter (I.D. and O.D.)*
3) *Fittings—size, type, style of thread*
4) *Tolerances permitted*
5) *Quantity required*

B OPERATING REQUIREMENTS:

1) *Material to be conveyed*
2) *Operating pressures—is there shock?*
3) *Operating temperatures*
4) *Movement—lateral and longitudinal*
5) *Vibration conditions?*
6) *Expansion and contraction requirements?*
7) *Corrosive atmosphere?*

Send sketch of proposed installation if available.

2 Use standard metal hose where possible

Many standard connectors have been developed to meet problems common to many finished products—i.e., vibration. Often a standard metal hose will answer your needs as well as a special item could. We can often save you money if we know operating requirements.

3 Call the Man from Anaconda to help you select, specify, test

When selecting or specifying flexible metal hose, you'll find American's staff of trained engineers of invaluable assistance. Their advice and suggestions may help you solve or avoid many costly problems.

NEW INFORMATION

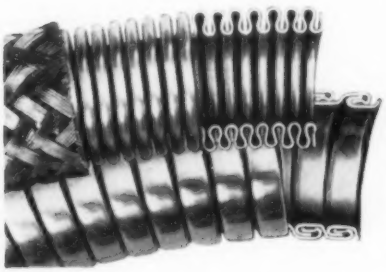
American Flexible Metal Hose and Tubing Catalog puts all the information you are looking for—both technical and general—at your fingertips. Get your copy—today, free of charge. Mail coupon below. 581668

WHEREVER CONNECTORS MUST MOVE

AMERICAN

FLEXIBLE METAL HOSE AND TUBING

an **ANACONDA**® product



BASIC TYPES

CORRUGATED and STRIP-WOUND. In a wide range of sizes and styles in any workable metal: Bronze, Brass, Aluminum, Stainless Steel. Various fittings.

THE AMERICAN BRASS COMPANY
American Metal Hose Division, Waterbury 20, Conn.

Please send me your free, 60-page Catalog G-560 containing basic information on all types of metal hose and tubing, fittings, etc.

NAME & TITLE .....

ADDRESS .....

COMPANY .....

CITY, ZONE, STATE .....

answering your demand for C

PORCELAIN ENAMEL

gives you greatest freedom of choice

RICH COLORS OR DELICATE PASTELS

You have practically unlimited choice of colors when you use Porcelain Enamel—from pastels to strong, rich hues. Outstanding effects can be had by using several colors, or two-tone or mottled designs for major areas or trim.

WON'T RUST, FADE OR STAIN—LASTS FOR LIFE!

Permanence is a virtue of Porcelain Enamel greatly appreciated by users of products made with this material. It withstands aging, weathering, corrosion, abrasion and abuse better than any other finish. Long life is an added sales point Porcelain Enamel can give your products.

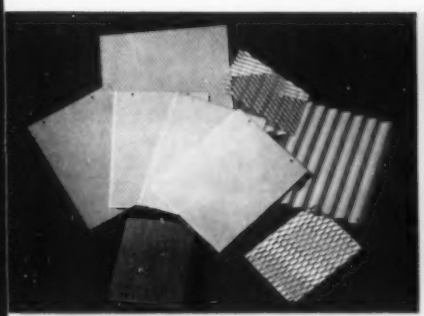
WIDE RANGE OF TEXTURES AND PATTERNS

The many attractive textures and patterns available in Porcelain Enamel give further opportunities to develop interesting designs. Many beautiful standard textures are available, and special ones can be developed. And the embossing or corrugating process makes the material stronger and more rigid!

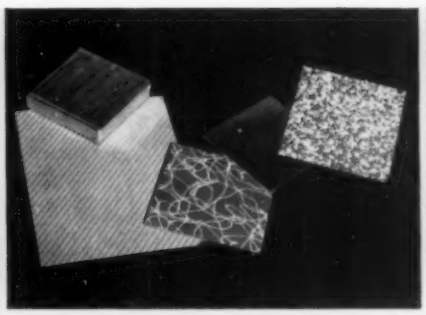
—AND EXCELLENT PHYSICAL AND CHEMICAL PROPERTIES

In addition to beauty and color, Porcelain Enamel provides many very useful engineering properties. It is glass-hard, steel-strong, and resistant to alcohol, chemicals, gases, moisture, flame, sunlight, thermal shock, abrasion, aging. Porcelain Enamel has a low coefficient of friction and high dielectric strength.

COLOR



INTERESTING EFFECTS, obtained with textured or patterned Porcelain Enamel, add greatly to the salability of many products. Corrugated and expanded metal are effective when finished with Porcelain Enamel.



COLORFUL PATTERNS give an endless array of designs that may be functional or decorative. Wood-grain and marble designs, pebbled and embossed surfaces give the designer wide latitude.

REFLECTIONS in these photographs show the difference between a highly glossy surface (left), semi-matte (center) and full matte. All are readily available in Porcelain Enamel.

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Contains much technical material never before available. Return this coupon for your copy.

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☐ Please send a copy of the new Engineering Data File.

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to_____
(type of product)

Name_____ Title_____

Company_____

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NEW FROM HONEYWELL!

THE "COMPLETE SAFETY" PROTECTOGLO*

FIRST AND ONLY COMPLETELY FAIL-SAFE FLAME SAFEGUARD

Listed and approved by the Associated Factory Mutual Laboratories and by Underwriters' Laboratories.

The need for protection in gas burner operation has been long recognized . . . and the subject of intensive research.

In 1951, a Honeywell advancement provided a "self-checking" operation at the time of burner startup . . . and spurred the search for full-time protection, because flame-safeguard components can and do fail "unsafely."

Now Honeywell, first again, offers a self-checking circuit that *continuously* supervises all system components. Never before has there been such complete protection . . . *protection you can't afford to be without.* Write for Specification S1015-5.

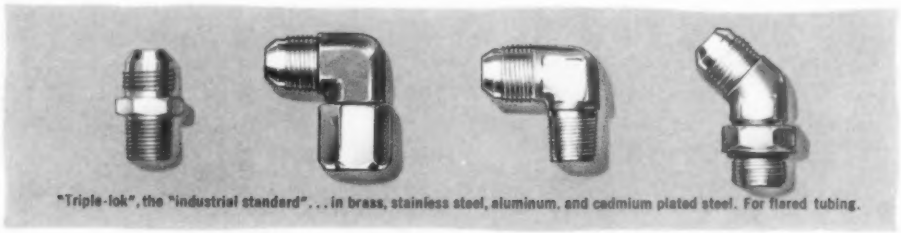
MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Honeywell

First in Control

"'A significant technical advancement" . . . at the A.G.A. Convention, Parade of Gas Progress.

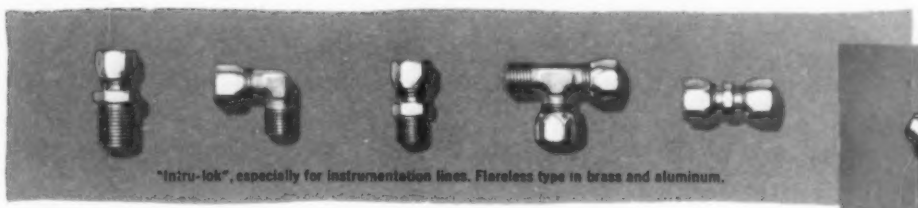
PARKER-HANNIFIN FLUID-SYSTEM COMPONENTS



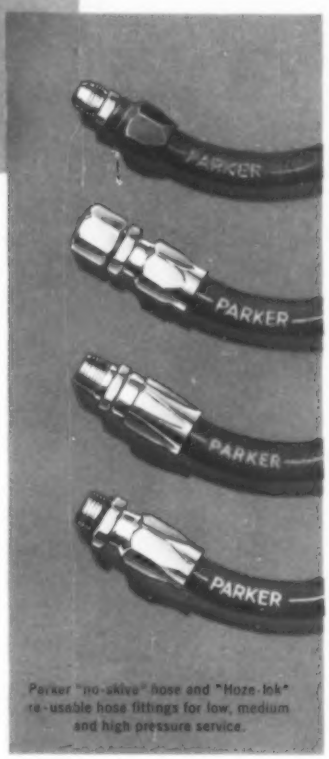
"Triple-lok", the "industrial standard"... in brass, stainless steel, aluminum, and cadmium plated steel. For flared tubing.

"Ferulok"®, the flareless type with the visible "bite", especially for heavy-wall tubing... in steel and stainless steel.

"Weld-lok" socket-type fittings, steel or stainless steel. Also "Braze-lok", in almost any metal.



"Intru-lok", especially for instrumentation lines. Flareless type in brass and aluminum.



Parker "no-skive" hose and "Hoze-lok" re-usable hose fittings for low, medium and high pressure service.

Only from Parker

such a wide range of fittings...so fast

If it's an industrial fitting, whether for tubing or for hose, Parker has it or can make it, in standard sizes in any metal.

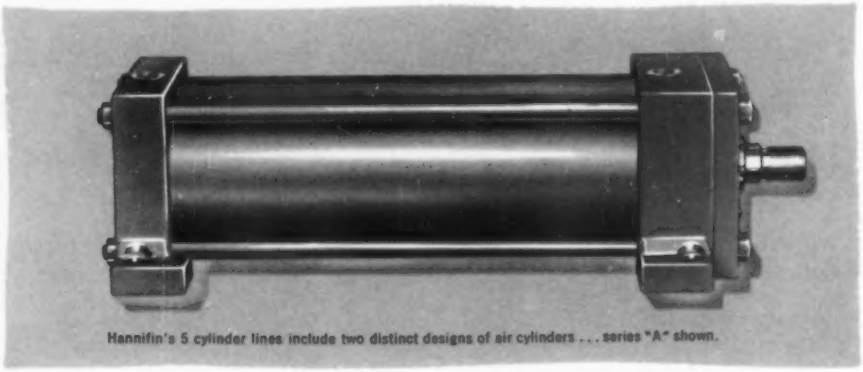
Parker "Triple-lok" for flared tubing . . . Parker "Ferulok"® for heavy-wall tubing . . . Parker "Weld-lok" for high-temperature, high pressure lines. ("Braze-lok", our newest line, does not require an open torch, is for medium temperatures.) "Intru-lok", for copper, aluminum or plastic instrumentation lines, requires no flaring. Parker hose and "Hoze-lok" re-usable hose fittings require no skiving of the hose.

There's a Parker distributor near you, write us for his name . . . call him for Parker catalogs.

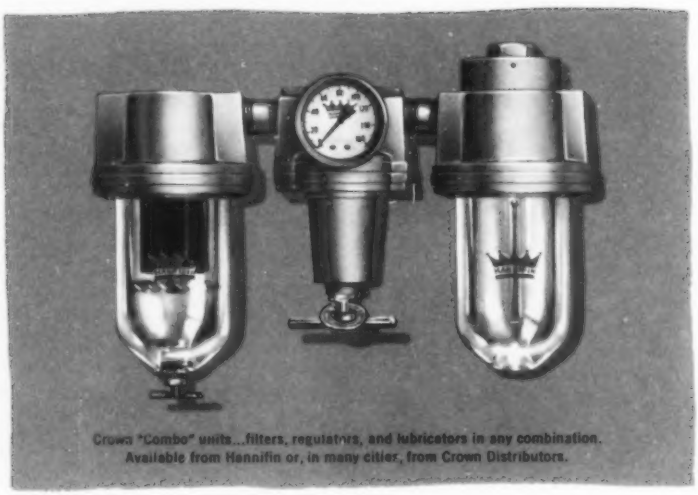
Parker Fittings and Hose Division
17325 Euclid Avenue • Cleveland 12, Ohio

A DIVISION OF PARKER-HANNIFIN CORPORATION

PARKER-HANNIFIN FLUID-SYSTEM COMPONENTS

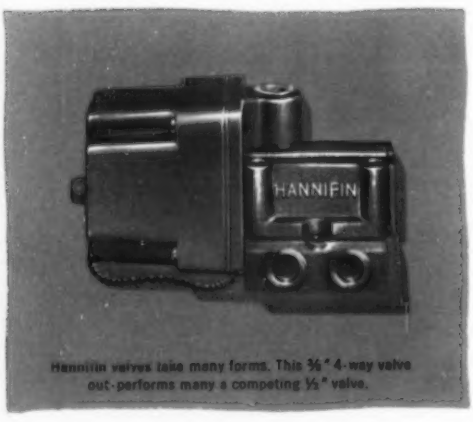


Hannifin's 5 cylinder lines include two distinct designs of air cylinders . . . series "A" shown.



Crown "Combo" units...filters, regulators, and lubricators in any combination. Available from Hannifin or, in many cities, from Crown Distributors.

Only **HANNIFIN** makes all these **AIR POWER COMPONENTS**



Hannifin valves take many forms. This ⅜" 4-way valve out-performs many a competing ½" valve.

Anywhere you use compressed air to do work, Hannifin can help you. Hannifin cylinders for the "muscles". . . Hannifin air valves for any type of actuation, hand, foot, cam, solenoid, or pressure . . . the Hannifin "Crown" Line of filters, regulators, and lubricators for lasting air power efficiency . . . all are built by Hannifin to just one standard, the best.

Turn to Hannifin, too, for expert help in applying air power components. A Hannifin field engineer is as close to you as your telephone, wherever you are. Write us for his address—or, he's listed in the alphabetical section of Thomas Register. It's that easy.

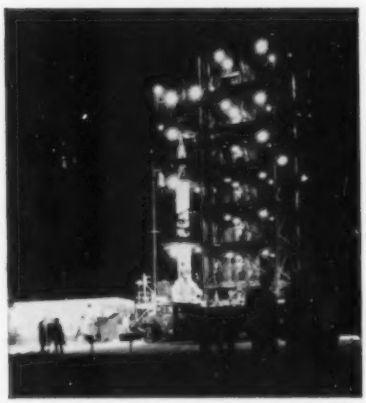
HANNIFIN COMPANY

505 South Wolf Road • Des Plaines, Illinois

A DIVISION OF PARKER-HANNIFIN CORPORATION

PRODUCT-DESIGN MEMOS FROM DUREZ

Insulative molding compounds | **Corrosion-resistant polyester** | **Low-cost control knobs**



Official U. S. Navy photo

But what if it rains?

From time immemorial, weather has upset the military plans of men. In colonial days, wet gunpowder could lose a skirmish. Today, one moisture-affected part can nullify months of costly labor on a new missile.

This helps to explain the increasing pressure on moisture-resistant insulations for electronic parts that must not fail. It explains, too, the growing interest in a relatively new Durez molding material, *diallyl phthalate*.

This is the *only* plastic that retains its high insulation values over extended periods at relative humidities above 90%.

Its arc resistance, as measured by ASTM D495 (Method A or B), can be consistently reproduced.

It does not corrode metal contact points.

Because it is a thermosetting material, it provides virtual freedom from cold flow and creep.

You can get this material from us as an orlon-filled granular blue or green molding compound with plasticity values of 10, 12, or 16 by ASTM D731. It is designed to meet the requirements of Mil-M-18794, Type SDI-5.

For a data sheet detailing properties of the compound, and of molded material, check the coupon.

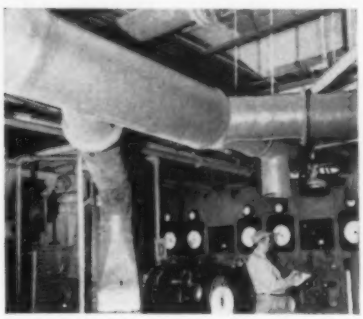
Hetron® ducts outlast metal

Perhaps you've been thinking of Hetron mainly as a *fire-retardant* polyester material.

It's true you get outstanding fire retardance with Hetron. But don't overlook its *corrosion resistance*, which is equally impressive in equipment such as this glass-reinforced ductwork manufactured by duVerre, Inc.

Venting corrosive fumes from a chemical reactor, aluminum ducts failed in 11 months. Ducts made of Hetron 92 replaced them—and have gone 17 months without a sign of deterioration.

In another plant, Hetron 92 replaces rubber-lined steel ductwork which lasted

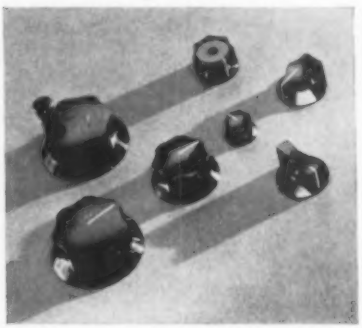


duVerre, Inc.

less than a year under the corrosive bite of wet chlorine. The Hetron ductwork, in service four years, has required no maintenance and is as sound as the day it was installed.

Because it is self-extinguishing, you can safely specify Hetron in many places where a conventional polyester won't do. Fire retardance is *inherent*—does not depend on additives that might dilute corrosion resistance.

Are you taking full advantage of Hetron's unique qualities? A check mark on the coupon will bring you an illustrated bulletin outlining properties and uses of the versatile Hetron resin family.



Ready-tooled knobs

Why tool up for a standard item like a control knob, when you can buy general-purpose knobs like these—probably at a good saving?

Many custom molders can supply knobs in Durez phenolic, from stock tooling, to fit most standard mountings. You can have them hot-stamped with numbers or characters; equipped with special motifs.

Styled as a family, they blend smoothly with modern equipment lines; wipe clean without dulling; and stand up to heat, dampness, and corrosive atmospheres. For further information, consult your molder.

For more information on Durez materials mentioned above, check here:

- ☐ Diallyl phthalate, Durez 16694
- ☐ Hetron polyester resins (bulletin)

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

DUREZ® HOOKER CHEMICALS PLASTICS

PLASTICS DIVISION
HOOKER CHEMICAL CORPORATION
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Booths 201, 203 and 205 at the Plastics Industries Exposition

←CIRCLE 116 READER SERVICE CARD

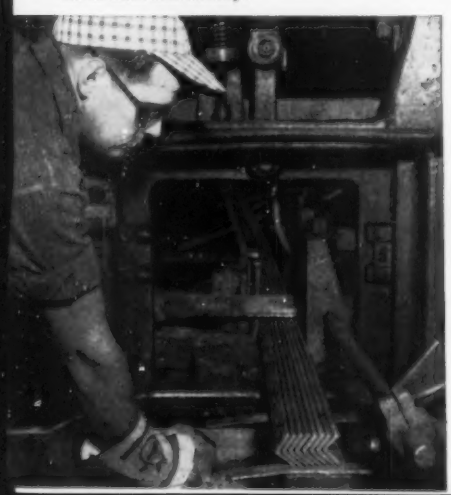
CIRCLE 117 READER SERVICE CARD

STEEL SHAPED TO CUT COSTS AND IMPROVE PRODUCTS

This is a picture of teamwork. C. G. Merker, U. S. Steel Metallurgist, discusses this cost-saving production change with Dick Sprucebank, Grating Shop Foreman, and Mr. P. H. Rawlins, Division Purchasing Agent.

Stair tread nose plate made in one operation from steel already rolled to shape

One operation – sawing – completed this nose plate made from a special angle section rolled with a raised tread on the top side. Sawing 8 to 10 bars at a time speeds up operations, saves time and money.



Blaw Knox Company, Pittsburgh, makes thousands of open grate stair treads yearly. The nose plate was previously fabricated in such a way that excessive scrap losses and high costs were often incurred.

To solve this problem, U. S. Steel suggested a special angle section with a raised tread rolled on the top side. This eliminated shearing and forming operations, and the resulting scrap loss. The nose pieces could be sawed 8 or 10 bars at a time from 20-foot lengths of steel. The result was substantial savings in cost.

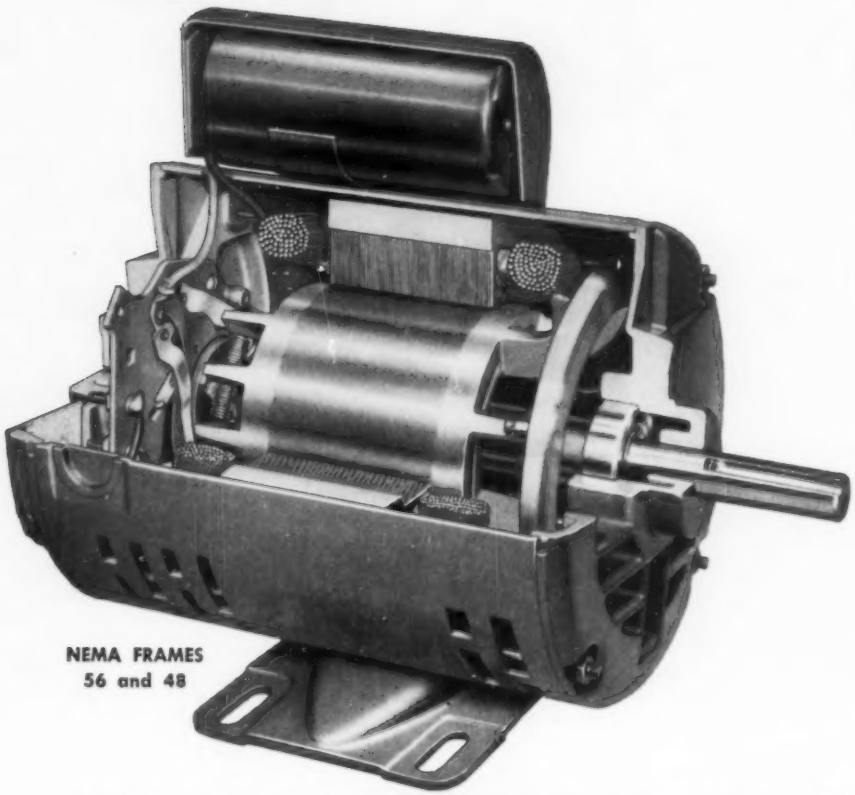
USS Special Sections can be made in many forms so that mass-produced parts can be cut to length as required and processed to finished parts by simplified fabrication. Frequently, this method will substantially reduce costs and result in improved parts. Why not write for complete information? United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS is a registered trademark

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Export Company

USS **United States Steel**

NEW R & M Fractional HP Re-Rated Motors



NEMA FRAMES
56 and 48

SPLIT PHASE

CAPACITOR START

PERMANENT
SPLIT CAPACITOR

POLYPHASE

MORE POWER...LESS WEIGHT AND SIZE!

Think of the advantages these new motors offer your products! Many new R&M Re-Rated Motors are less than half the weight of former designs. For example, the new R&M ¾ hp, 1725 RPM single phase motor weighs 26 pounds as compared to a former weight of 56 pounds. Performance, torque and overload service factors are well within national standards. Lightness and compactness have been accomplished by the selective use of lighter metals and more efficient double end ventilating.

Design versatility is an advantage too! R&M Re-Rated Motors in NEMA Frames 56 and 48 are available as complete "off the shelf" motors with a wide choice of mountings, bearings, mechanical and electrical characteristics in sizes from 1 to ⅛ hp. They're also available as motor parts without end heads. Write for Bulletin 450-PRE.

Robbins & Myers build motors from 1/200 to 200 horsepower

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NEMA C FLANGE

SPECIAL PURPOSE MOTORS

Where production quantities justify, experienced R&M application engineers welcome the opportunity to furnish a design best suited to your particular power requirements.

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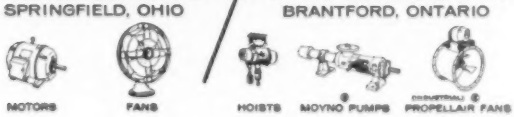
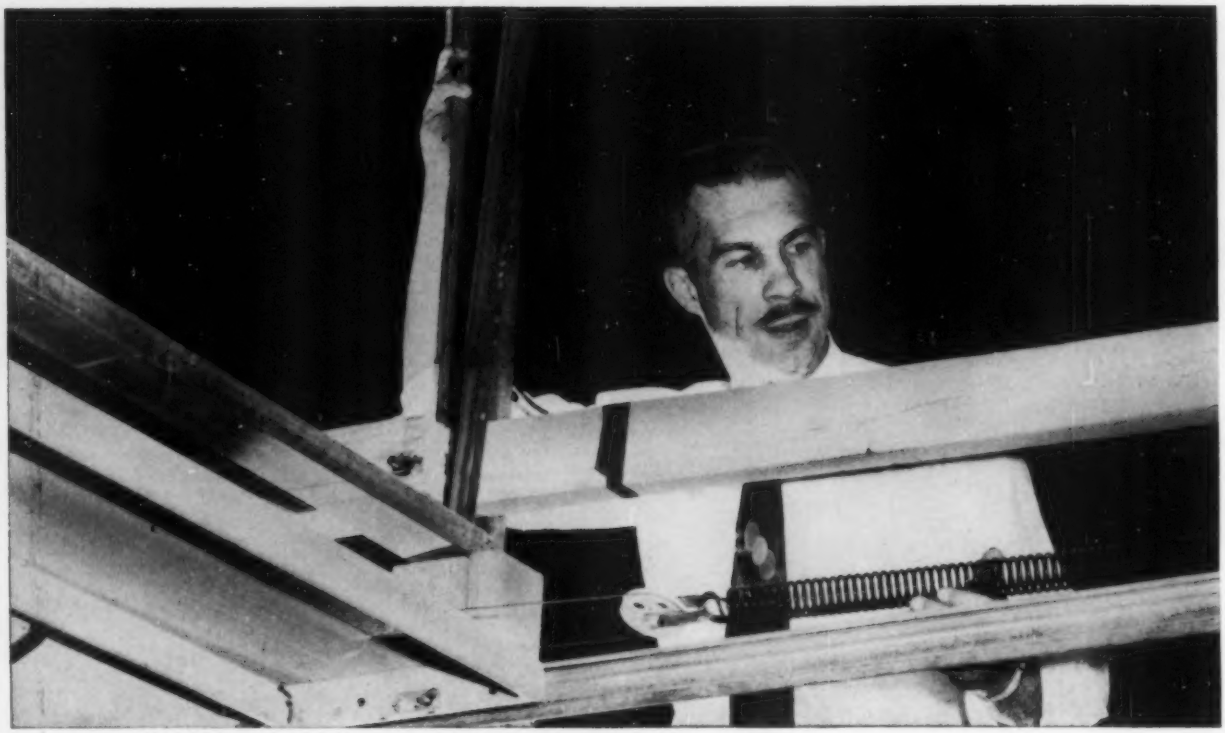
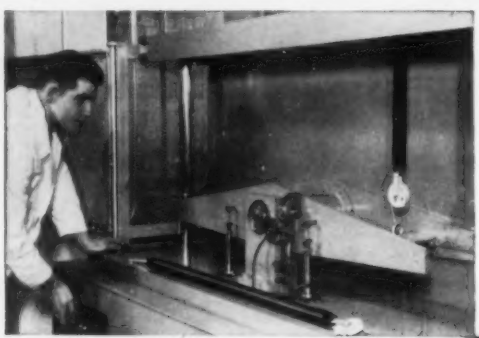


MOTORS FANS HOISTS MOYNO PUMPS INDUSTRIAL PROPELLAIR FANS



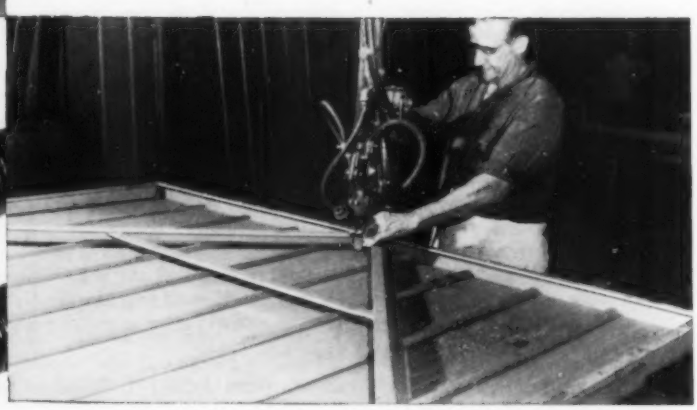


At Steel Door . . .

USS American Springs

thanks to AS&W

In the American Steel & Wire Fatigue Laboratory, a technician runs tests on a USS American Spring, designed for Steel Door use. On the basis of this test a change in hook design was recommended to give longer spring life.



A Steel Door workman assembles a Berry One-Piece Door. This company uses steel exclusively for all doors because of its many consumer advantages. Steel is stable, won't warp or swell. Steel doors need less maintenance and preparation, and steel doors are easy to operate.

This close-up shows the improved hook on the extension springs supplied by American Steel & Wire for the Steel Door overhead garage doors.

stretched 31,000 times and still going strong...

Spring Engineering Research Service

The Steel Door Corporation, Birmingham, Michigan, is the world's largest manufacturer of residential garage doors. For the production of these doors they use about 150,000 USS American Springs every year. Steel Door asked American Steel & Wire for a statistical evaluation of the fatigue life of the extension hook-type springs they use. The AS&W Spring Engineering Research Service tested these springs in the Fatigue Laboratory and recommended a change in hook design.

So successful was this design change that the life of the springs has been materially increased. At the Steel Door plant a cycle test was set up using USS American Springs on an overhead door. At the present time these springs have completed over 31,000 cycles without showing any sign of failure. This is the equivalent of 25 years of normal usage.

Mr. Ralph Qualman, Advertising Director and Service Manager, says: "It is extremely important that the springs—especially those used on sectional doors where the strain is greatest—have proper tension and a long life. American Steel & Wire supplies Steel Door with springs that meet their engineering specification and life expectancy."

If you have a spring problem or would like advice on the use of springs in your product, get in touch with our general offices in Cleveland, or any American Steel & Wire Sales Office. You can benefit from the knowledge of AS&W's Spring Engineering Research Service. The Service has been engaged in laboratory experiments of static and dynamic testing for 20 years and has accumulated invaluable data on stress and fatigue life of steel springs, while endeavoring to improve efficiency in the use of steel—from steel chemistry through product application—to more economically cope with today's rigorous demands. This accumulated knowledge of the AS&W Spring Engineering Research Service is at your disposal. *American Steel & Wire, General Offices: Rockefeller Building, Cleveland 13, Ohio.*

USS and American are trademarks

American Steel & Wire Division of USS **United States Steel**

Columbia Geneva Steel Division, San Francisco, Pacific Coast Distributors • Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors • United States Steel Export Company, Distributors Abroad

MELAMINE PARTS MADE
BY CHICAGO MOLDED

CUT BOTH COST AND WEIGHT 75%

make new design and color styling practical

Chicago Molded makes four plastic parts for new photocopier.

This melamine housing and cover are features of the new Apeco Uni-Matic Auto-Stat copying machine. Two other important components – the processor tank and removable trough – are injection molded of styrene-acrylonitrile copolymer by Chicago Molded Products Corporation.

American Photocopy Equipment Co. of Evanston, Ill. estimates that the molded melamine housing on their new Apeco Uni-Matic photocopier *alone* saves $100 on the machine's retail price. The plastic housing also has a 4-to-1 weight advantage over stainless steel, and offers far greater latitude of design and styling. The offsets and crisp contours embodied would have required complicated fabrication and been economically impractical in drawn metal. The melamine housing emerges from the mold ready for assembly. Melamine also makes available to Apeco a wide selection of molded-in colors.

Supplementing the melamine housing and cover are two other important components that Chicago Molded

makes for the Apeco Uni-Matic Auto-Stat. These are the processor tank and removable trough – both injection molded of styrene acrylonitrile. This copolymer gives these transparent parts improved impact resistance and immunity to attack by the developing solution used in the photocopier.

These savings in weight and cost – plus the design and styling advantages – are typical of how Chicago Molded engineers can help make your products better, more saleable, *lower priced.* With more than 39 years of experience in molding all kinds of plastics, Chicago Molded can suggest better molding materials, cost-saving techniques, even basic design changes.

For information on Chicago Molded's services and a free subscription to *Plastics Progress*, the data-packed magazine on new developments in plastics, write today to:

CHICAGO MOLDED
PRODUCTS CORPORATION
1032 North Kolmar Ave., Chicago 51, Illinois

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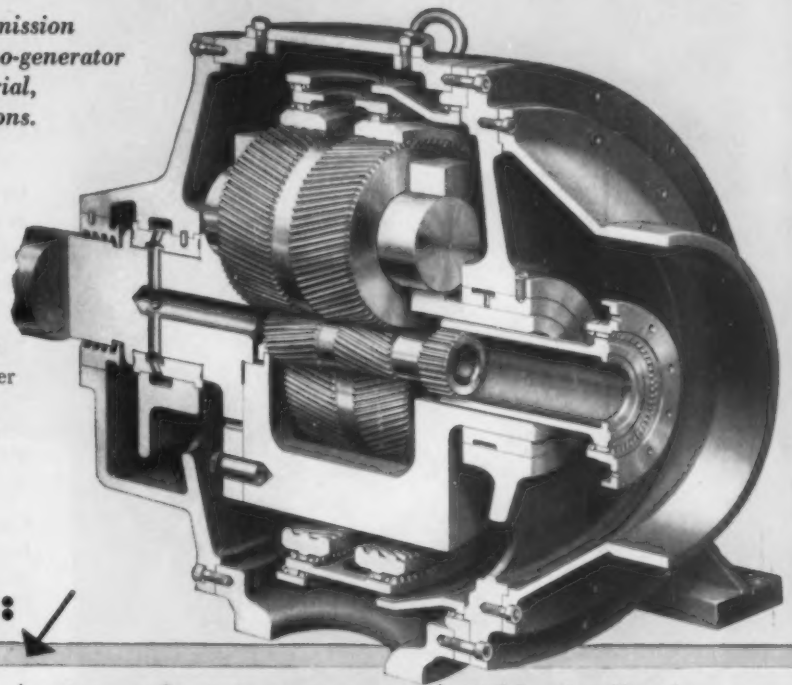
DE LAVAL-STOECKICHT
PLANETARY GEAR

...for high speeds...high horsepower

Proved in hundreds of installations abroad totalling over 3,000,000 horsepower—now available in America!

For all high torque power transmission applications such as pump turbo-generator and compressor drives in industrial, municipal and marine installations.

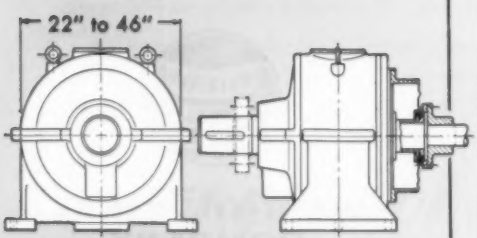
This cutaway view of the De Laval-Stoeckicht Planetary Gear shows how it provides flexibility for proper load distribution throughout the gear members. The thoroughly proved and tested design is completely reliable in transmitting high horsepower for high speed applications. • Highest efficiencies (98% or higher)...no high speed bearings...less friction losses.



Check These Advantages:

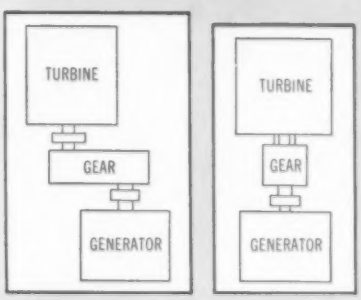
Small Size—Light Weight

Compact—low weight per hp. Sizes range from 22" to 46" in diameter, depending on horsepower requirements. Example: 5000 hp planetary unit weighs 1700 lbs. against 6000 lbs. for conventional gear.



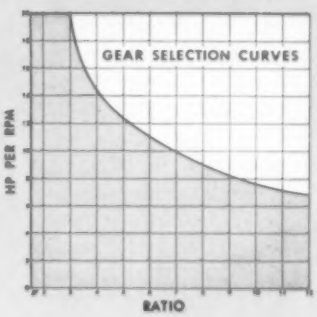
Convenient Arrangement

Co-axial or "in-line" arrangement of gear members takes up far less space than parallel axis gears of equivalent horsepower rating.



Wide Application

Capacity range shown in shaded area on chart below. For other applications, contact your De Laval Sales Engineer.



For further details, write for Bulletin 2400.

DE LAVAL *Steam Turbine Company*

801 Nottingham Way, Trenton 2, New Jersey

"We just don't worry about chipping or flaking when we lock-seam WEIRKOTE®!"

If those difficult lock-seaming operations give you trouble, it's time to take the step that leading manufacturers everywhere are taking.

Switch to Weirkote zinc-coated steel as promptly as you can.

Weirkote's continuous process integrates the zinc and the steel so that the most complicated forming operations are made without chipping or flaking. Weirkote can be worked to the very limits of the steel itself—spinning, deep drawing, crimping, twisting, the works. Comes through in perfect shape to give your products lasting anti-corrosion protection, such as they've never had before.

Weirkote's made that way to behave that way.

Can you think of a quicker, easier step to an even better product? To fewer rejects? To more peace of mind? To lower costs? And, perhaps most important, to the greater good will of customers who receive even more value for their money?

Write today for the free booklet that will give you lots of food for thought on the many advantages Weirkote can bring to your products and production. Weirton Steel Company, Dept. D-1, Weirton, West Virginia.

WEIRTON STEEL COMPANY

WEIRTON STEEL COMPANY

WEIRTON, WEST VIRGINIA

a division of

NATIONAL STEEL CORPORATION

Faster reference . . . Faster printmaking

with Recordak Precision Engineering Drawing System

Sharp, clear microfilm image enlarged in Recordak Film Reader is easy to work with — always instantly available

Handy-size Recordak prints made from 35mm microfilm are as readable as original drawings — end need for bulging paper files

NOW you can have a complete file of drawings at your fingertips . . . instead of in distant files! You'll be able to check any drawing in seconds in a Recordak Film Reader . . . get 9-inch, handy-size paper prints for pennies a copy —much faster, much cheaper than any other way!

Don't confuse this Recordak System with other methods. Recordak offers unique microfilm picture quality perfected in years of research and development; *35mm microfilm negatives that faithfully reproduce your originals down to last detail!*

All types of drawings, negative and positive prints—old or new, clean or dirty—can be reproduced on Recordak 35mm microfilm. Ends need for costly, larger size films. And the next step—mounting each negative on its own Filmsort aperture card *provides an active drawing file that takes 95% less space.*

Free booklet explains new Recordak Engineering Drawing System in detail . . . tells how it can be tied into existing, mechanized filing and duplicating installations for even greater savings.

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Gentlemen: Send free booklet describing new Recordak Engineering Drawing System. No obligation whatsoever.

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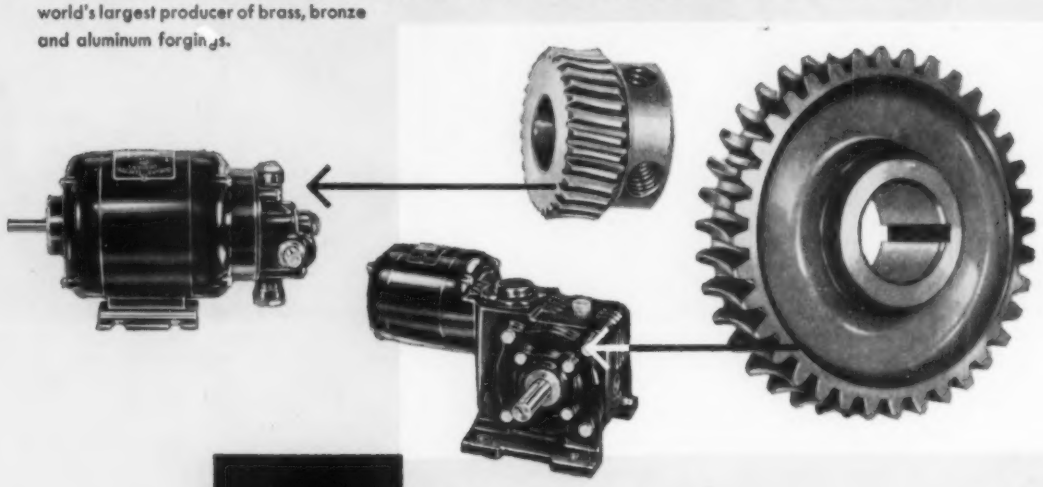
MUELLER BRASS CO. forged gears improve dependability and performance of BODINE electric motors

For combined high shear strength and maximum wear life in their single and double reduction speed reducer motors, Bodine Electric Company of Chicago uses gears forged from Mueller Brass Co. 603 Alloy.

Bodine has specified Mueller Brass Co. forged gear blanks because of their consistently high quality . . . there is no porosity, foreign inclusions or defects typical of cast blanks. The hot working of the metal followed by heat treatment to the desired physical properties produces a refined grain structure to give uniform machining and wear in service. The forged blanks are consistent in size and held to close tolerances. Bodine has also found that the excellent machinability of the blanks in the hobbing operation increases overall hob life.

For forgings of high tensile strength, high density, minimum porosity, light weight, corrosion resistance, good machinability and low costs with little scrap loss, it pays to specify forgings from the Mueller Brass Co., the world's largest producer of brass, bronze and aluminum forgings.



only the man from Mueller Brass Co.

can offer unbiased advice on the "one best way" of producing your parts, because Mueller Brass Co. is the *only* fabricator in the country offering all these methods of production . . . assuring you the best product at the best price . . . made the one best way.

Write today for complete catalogs on any of these products.

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PLASTICS INJECTION MOLDING

COLD-PREST IMPACT EXTRUSIONS

SCREW MACHINE PRODUCTS

POWDER METAL PARTS

RED BRASS CASTINGS

Also producers of: Super Cutting Red Tip Brass Rod • Aluminum Extrusions Aluminum Sheet, Coil and Strip • Plastic Pipe and Fittings • Copper Tube and Solder Type Fittings •

MUELLER BRASS CO. PORT HURON 22, MICHIGAN

This vacuum truck has never choked on anything...

Because it's equipped with a Rockwood Valve

These vacuum trucks spend all day sucking out tank bottoms, or sucking up drilling mud and miscellaneous trash from old well sites. It's a tough job to say the least. It used to be an ugly one, too, with a lot of expensive breakdowns — but now that these trucks have Rockwood Ball Valves, things are coming up easy.

Rockwood Ball Valves don't even choke on such troublemakers as pop bottles and coffee cans — yet that's not all. Rockwood Valves also have these all-important features:

- *Full, Round Flow* every time — no change in shape or volume of stream — minimum loss from friction.
- *Leakproof Seal* — exclusive corrugated spring design and fluid pressure automatically position ball against seat to form tight seal, and is particularly successful on dirty fluids.
- *Long Wear-Resistance* — chrome-plated bronze ball withstands abrasion, pitting, scratching.
- *Quick Opening and Closing* with only a quarter turn.

Write for the details today. Valves in all pipe sizes, tested and listed by Underwriters' Laboratories, Inc. Distributors in all principal industrial areas.

ROCKWOOD
BALL VALVES

ROCKWOOD SPRINKLER COMPANY
1125 Harlow Street
Worcester 5, Massachusetts

Send me your new Rockwood Full-Flow Ball Valves Catalog No. 57.

Name ..... *Title* .....

Company .....

Street .....

City ..... *Zone* .... *State* .....

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By John S. Davey

The strength of nuts

With a hard, heat treated nut, ability to plastically adjust and distribute load over many threads diminishes. High loads tend to concentrate on first thread severely enough to cause stripping . . . or fracture of first thread, which causes locking. Nut then cannot increase tension in bolt.

Untreated nuts are strong enough for most needs, and don't pose this problem.

A CAUSE OF STRIPPING

Upon tightening, a nut both compresses and dilates. Dilation can be overcome by wall thickness only, not by added height or heat treatment.

Dilation is important since a reduction in area of bolt under tension accompanies it. Threads pull away from each other, from their stronger base to weaker tips. The shallowness of *fine* threads can cause progressive shear.

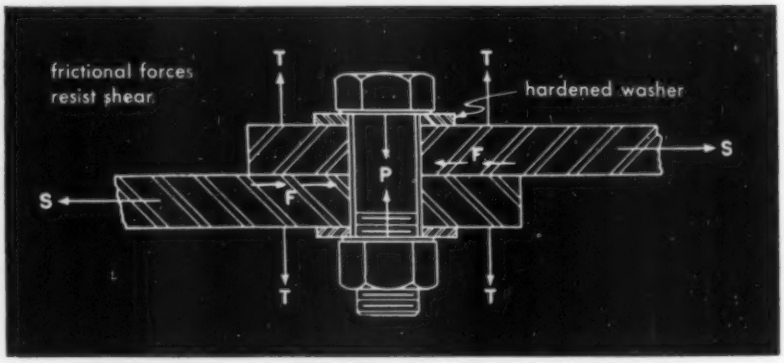
That's why High Nuts (with fine threads) are no answer where "Heavy" Nuts (with coarse threads) are.

WRENCHING STRESS HIGHEST

Rotation of nut produces both tension and torsion in bolt. The force applying this combined stress is about 20% greater than the load which must be sustained when rotation stops.

Thus . . . if a nut hasn't failed in wrenching, it can still withstand at least 20% more direct pull than it sustained during the tightening.

Why high strength bolts make superior joint for dynamic loads



Washers prevent crushing under head and nut with consequent grip relaxation.

While fasteners must be strong enough to carry the calculated loads, what makes a *joint* truly strong is the *residual tension* after wrenching.

NO SLIP OR SEPARATION

Consider the simple lap joint in sketch. Practically rigid, this joint is subjected only to: (1) external tension forces "T" tending to separate the plates against bolt clamping force "P"; (2) shear forces "S" tending to make plates slip against friction resistance "F".

"F" increases when "P" does. With enough clamping force applied, shear loads transfer from one plate to the other without slippage. And when clamping force always exceeds tensile forces, plates obviously *cannot* separate. There can be no further stretch on bolt. Its load stays static at preload "P", even when external loads are dynamic.

UNIFORM CONTROL OF PERFORMANCE

RB&W high strength bolts allow a high magnitude of clamping force to be applied . . . and *uniformly* so. Materials conform to ASTM specifications. Applying known torques to nut produces uniform bolt tensions. Riveting by contrast, depends on difficult-to-control variables.

MORE STRENGTH OVERALL

For shear-resistance, riveted joints offer only the actual rivet shear strength. Don't count too much on friction even though rivets exert some grip as they cool. Compare: a 1-inch bolt tightens to a tension of 42,000 lbs; a 1-inch rivet develops 22,000 lbs at best.

The higher residual tension does more than make a joint much stronger in shear and in tension. It also protects the bolt against fatigue caused by stress-reversing cycles such as vibration; keeps the bolt from loosening, too.

All this explains why, under heavy dynamic loads, rivets can loosen, elongate holes, often fail, requiring difficult replacement; but high strength bolts stand up. They can keep connections permanently tight on vibrating machinery, heavy duty conveyors, and transportation equipment.

Talk it over with an RB&W fastener expert. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N. Y.

RB&W high strength bolts are from selected grade of medium carbon steel with proper combination of ductility and tensile strength; conform to ASTM A325.

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

PERSPECTIVES

in design and development . . .

Science-oriented Engineers

At the recent American Ceramic Society meeting, Dr. E. L. Kreidl, chief of the Physical Science Section at Arthur D. Little Inc, said, "Industry can't face the burden of fundamental research alone . . . We are working dangerously close to the limits of our knowledge. The scientist is not ready for the engineer, and the engineer is not ready for industry."

Will this, then, eventually result in an engineer type that some educators are predicting—the "science-oriented" engineer? Perhaps he is already here. The electrical engineering department of many large engineering schools has become almost a science department. There are many examples—in missile electronics, low-temperature superconductivity, direct conversion of heat to electricity, solid-state technology, etc—where engineering advances go hand in hand with scientific advances.

As part of this trend, the newer fields often appear more glamorous than the older ones. One result, says a dean of engineering, "is that the relationships often become strained. Some electrical engineering departments, for example, feel that challenging subjects are attracting the cream of the student crop to the science-oriented fields. This doesn't sit too well." Mechanical engineering departments are trying to fight back by developing their own science-oriented engineer who will be able to cope with coming problems in materials. In both cases—electrical and mechanical—additional major requirements for the science-oriented engineering student are physics, metallurgy and chemistry.

More PhD's

These extras automatically lead to higher degrees in most cases, and the call now is for more graduate students, particularly those working towards their doctorates. US colleges are producing Phd's at a rate of *600* a year. This is not enough, particularly in rapidly advancing fields.

Most US colleges begin urging their students to start graduate work shortly before they graduate. MIT is developing a pre-engineering type of program for those students who decide after their second undergraduate year to go on to a graduate degree. A curriculum leading to a BS degree often doesn't provide adequate preparation in math and physics.

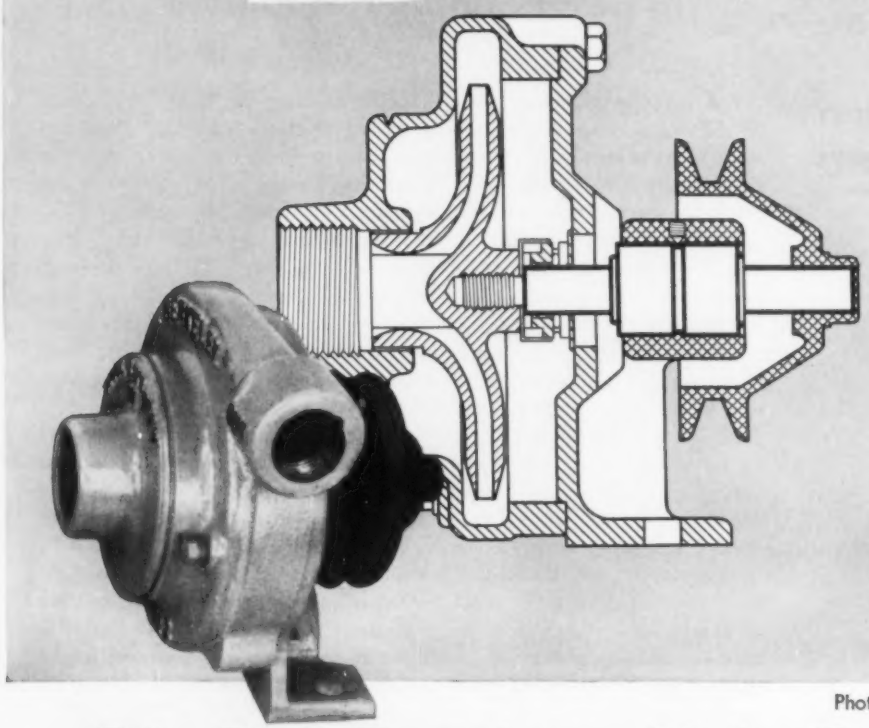
The Other Side

There are groups in engineering education who oppose the "scientist" trend on grounds that the function of the engineer in society differs from that of the pure scientist. The engineer must make a variety of decisions normally outside the realm of the scientist.

Perhaps the easiest compromise is to say that the engineering field needs both types—the applied scientist and the more empirical engineer. Some schools have progressed along these lines in recent years by introducing a new curriculum generally referred to as engineering science, but, as J. A. Stratton, president of MIT, said in his 1958 report, "The more deeply one delves, the more elusive the answers appear, the less easy their resolution. There is serious objection, for example to concentrating a faculty of applied science in a single new department for this concentration obviously must take place at the expense of our present fields of specialization. Doubts have also been expressed as to whether, in the long run, parallel options—one centered in applied science, the other expressing the more traditional approach to engineering education—can successfully coexist in one department."

—Paul Anderson

CASE HISTORIES



Compact integral shaft and bearing unit eliminates parts—cuts assembly time.

Photo: Courtesy Berkeley Pump Co.

Ball Bearings Help Cut Size... Lower Costs $2.50 Per Pump!

CUSTOMER PROBLEM:

Redesign utility water pump for Air Conditioner market. Conversion must achieve smaller size without reducing pump capacity. At the same time, customer must lower over-all production costs.

SOLUTION:

N/D Sales Engineer suggested the versatile New Departure fan and pumpshaft ball bearing. This compact precision bearing permitted use of over-the-housing pulleys with belt load located over the raceway. Its integral shaft, which is the inner race, simplified design and helped reduce housing size without changing pump capacity. In addition, the sealed and lubricated-for-life bearing replaced two sealed bearings, separate shaft and snap rings . . . cutting part and assembly-time costs $2.50 per pump.

Perhaps one of New Departure's wide selection of *production* ball bearings will help give *your* product the sales appeal and cost savings you're looking for. For more information, call the New Departure Sales Engineer in your area or write Dept. P-11.

Available through United Motors System and its independent Bearing Distributors.

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

Product Engineering

November 24, 1958

is DESIGN just gadgetry?

Detroit, according to recent news reports, plans still more powered gadgetry on forthcoming models—pushbutton doors, trunk lids, hoods, sliding tops. These despite present pushbutton complications with operation and maintenance and poor gasoline mileage. An auxiliary engine is predicted, to power the gadgets—or a still bigger prime mover.

Why? Because the American public is "gadget-happy," because it "has the money," because it bought power steering and braking, power seat adjustment, power window lifts. Because, led by the automotive industry, American manufacturers have convinced many buyers that fundamental design, sound engineering, coordinated interior and exterior planning are not nearly as important as "style" and ostentation.

We are not only gadget-happy, but also gadget-hungry. Solid worth, long life, safety—these are afterthoughts when we buy, if thoughts at all. We buy for "conspicuous consumption."

Our products are moving steadily toward surface appearance, an endless parade of chromium-plated metal that is too thin, brightly colored plastics that smash at a touch, design that apes a momentary craze. We have elaborate circuits where simple ones would do, extra lights, knobs, buttons. The next step is nuclear elements, whether needed or not, because they're in the news.

It is not the engineer or the designer who is at fault in all this. A key factor is skyrocketing costs, of course, so the pressure is always on to skimp on materials, mechanisms, circuitry, finish quality—and to hide these soft spots with tricky appearance and sales slogans.

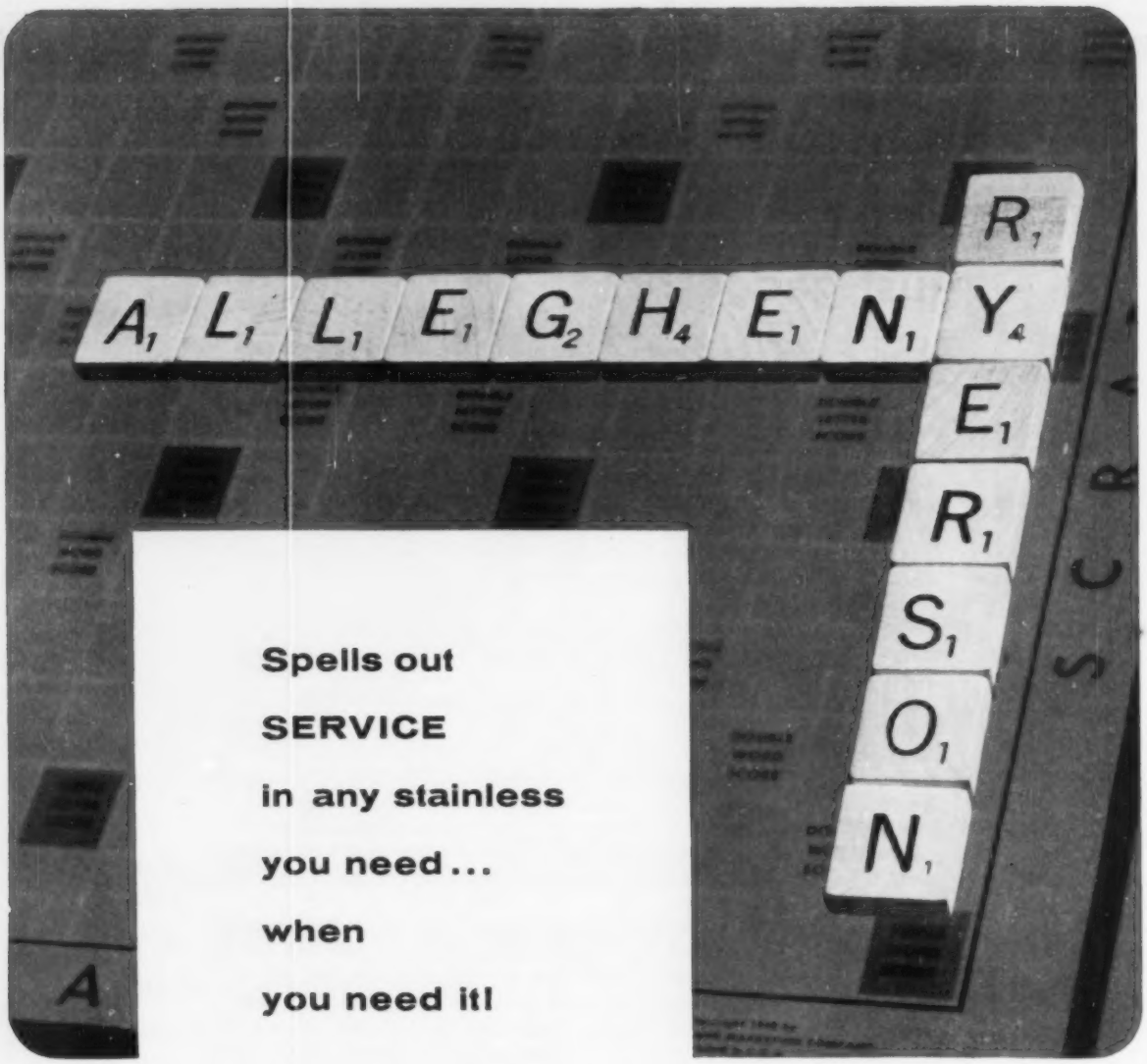
But, much more important than that is the ignorance of the buying public. They swallow unsupported claims. They buy the gadget, the gimcrack, because they know no better. They're very conscious of style and mode, but not at all conscious of solid workmanship and sound quality. And a great many present-day merchandising campaigns encourage this emphasis. Into the ears and eyes of the ordinary citizen, from morn to night, pour the honeyed words of the apostles of the fast buck. It's smart to have what everyone else has—to be herd-bound by gadgetry.

The manufacturer who tries to put solid worth into his product finds himself hamstrung by competitors who don't. The doctrine of "planned obsolescence" is carried so far that the product can scarcely hold together for shipment. And maintenance is so difficult and unreliable that replacement is easier.

It is far past time for the pendulum to swing the other way—for the buyer to learn how to pick the quality product. There are evidences that it is swinging—the do-it-yourself movement, the resistance to bechromed Juggernauts, the inexplicable "buyers' strikes." The man with a home workshop, the amateur scientist, the sports-car addict, the sportsman who has abandoned the spectator role—all are learning about the importance of quality in products. More and more, they will insist upon quality in everything they buy—or they won't buy.

Then the designer will again come into his own over the stylist, and a chastened sales department will recognize that superior design beats cutthroat pricing.

Experience**—the extra alloy in **Allegheny Stainless



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Allegheny Ludlum is the leading producer of stainless steels in all forms. Ryerson is recognized as the top steel service center. It's a team to bring you the best quality stainless, quick, when you need it.

Ryerson now stocks 2,351 shapes, sizes, finishes and alloys of Allegheny Stainless. It's the most complete line of stainless anywhere! And Ryerson takes the inventory cost from you, gives you as quick service as your own stockroom.

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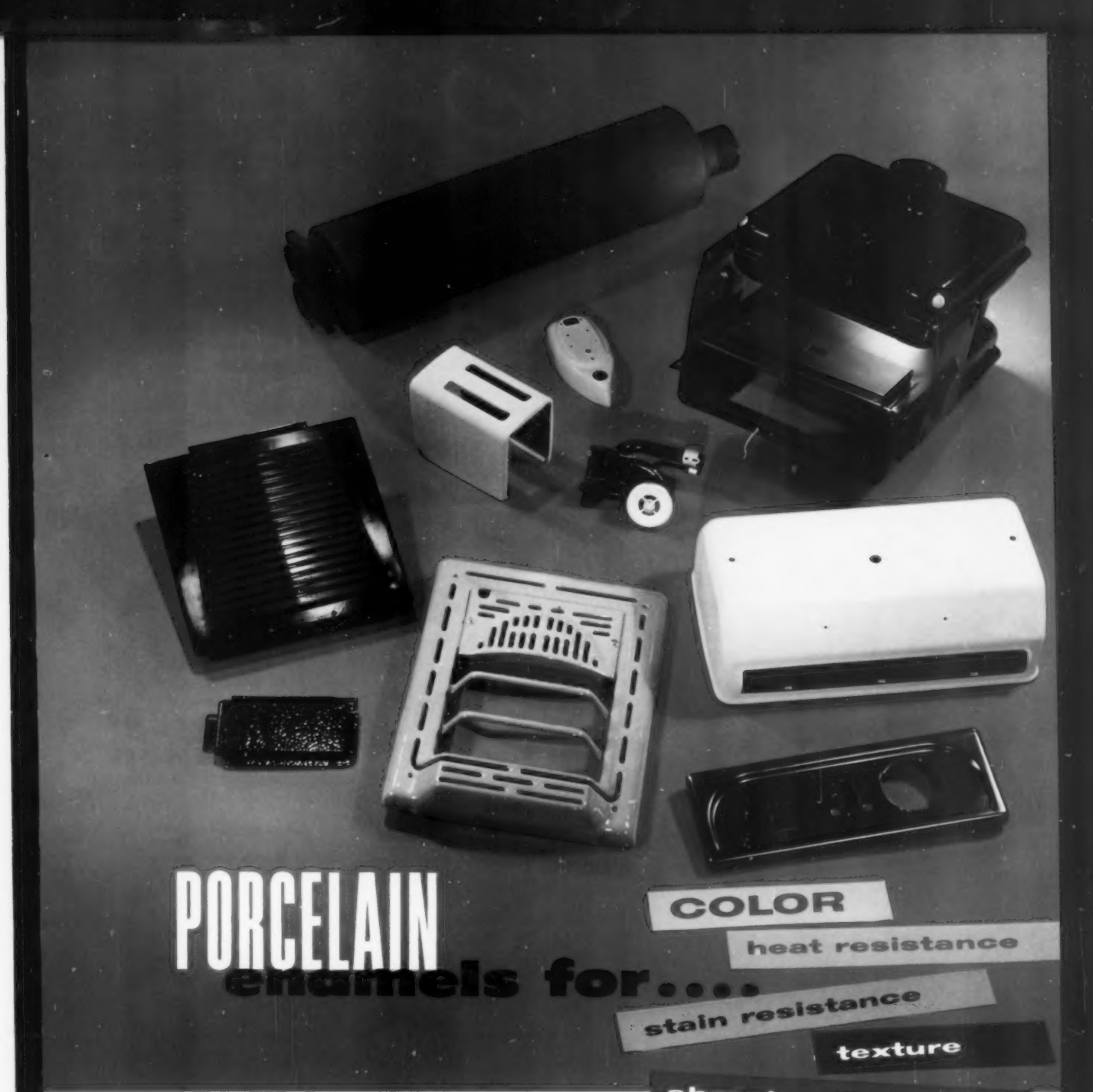
EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT



WILLIAM E PIERCE

Manager, Product Engineering Dept, Porcelain Enamel Institute

Coating with porcelain enamels is no longer as simple as just picking a gleaming color — or one of the new patterns. It's also important to know the engineering properties concerned, and the best process for the application. For the story — clarified in chart and pictures — turn page →

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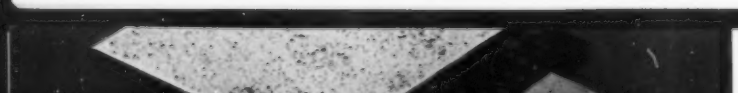
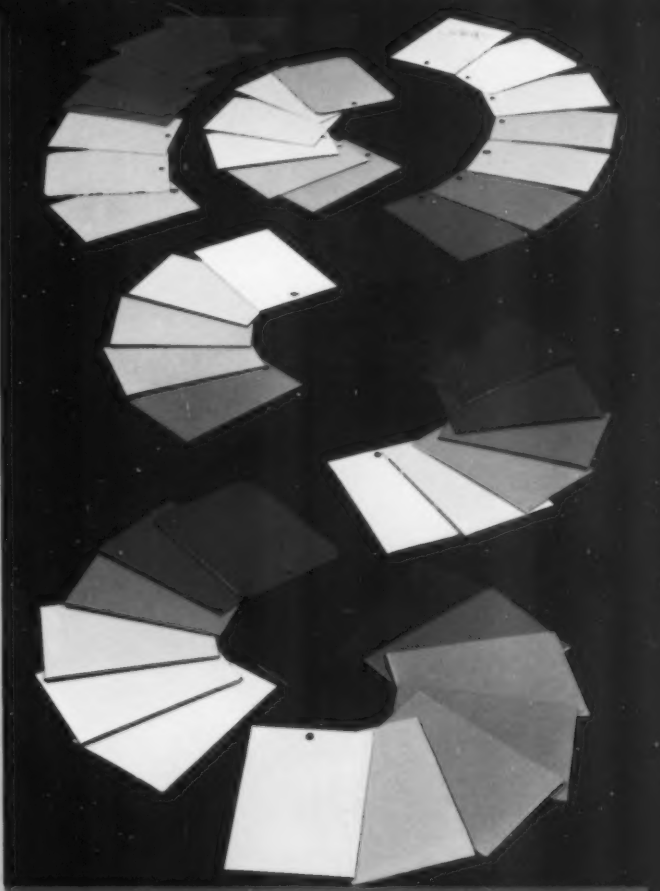
Decorative Processes for Porcelain Enamels

	Typical Applications	Advantages	Limitations	Visual Effect	Texture	Cost
Stippling or Speckling	Space heaters Oven linings Flame-heated appliances	Low cost Good thermal-shock resistance Covers minor surface defects	Over-all pattern only	Spots or speckles of one or more colors on background	Pebbly, usually glossy	Relatively low
Veining	Stoves Appliances Interior architectural parts	Effective for large areas One-fire finish possible Covers sharply curved surfaces	Not suitable for detail designs or small areas	Line pattern in contrasting color over base color	Smooth, usually glossy	Relatively inexpensive
Polytone	Stoves Air conditioners	Eliminates distracting reflections	Large surfaces only Flat or convex areas	Multicolor graining Rough textural shading	Uneven, glossy	——
Graining and Marbleizing	Table tops Cabinets and enclosures	Over-all pattern on large pieces in quantity	Large, flat panels only	Wood-grain, marble Any design that can be printed from a roll	Usually smooth and glossy	Low cost
Stenciling and Brushing	Stoves Appliances Signs	Low cost for short runs Reduced thickness prevents chipping	No fine detail Firing after each color Cannot cover highly curved surfaces	Solid areas of color overlying base color Color areas sharply defined	Smooth, usually glossy	Low stencil cost but high labor-per-piece cost
Printing	Labels for trademarks or identification	Small designs in fairly fine detail For irregular parts	Design not accurately positioned	Small designs or lettering	Smooth, glossy	Low cost
Decalcomanias	Labels for trademarks or instructions Decorative art	Best method for fine detail in several colors For any shape	Small sizes Skill required Applied on fired finish coat	Multicolor designs in fine detail	Smooth, glossy	——
Silk Screen	Operating instructions, trademarks Halftones, intricate patterns	Fine detail with unskilled labor Low cost for long-run multicolor halftones	For small areas Cannot cover highly curved surfaces	Fine-detailed design (solid color or halftone dots)	Smooth, glossy Screen texture may remain	High screen cost
Embossing (as a preliminary)	Cabinets Enclosures Structural panels Appliances	Adds stiffness Reduces objectionable reflections Nonskid surface	Requires metal-forming equipment or textured metal stock	Patterned, raised design	Same as the textured metal base	Increased base-metal cost





The full spectrum . . .
of color can be had in porcelain enamels.

Decorative color for silver and gold was the first job given to porcelain enamels, but when their protective properties were discovered, color then took second place. Parts coated with these enamels took on the familiar white and dark blue so common in sanitary ware and housewares. But now color has made a comeback and porcelain enamels are a leading contender in the decorative-color field.

Specifying a porcelain-enamel color, however, doesn't mean merely choosing from a color chart. Each type of finish has its own pattern, texture, and luster.

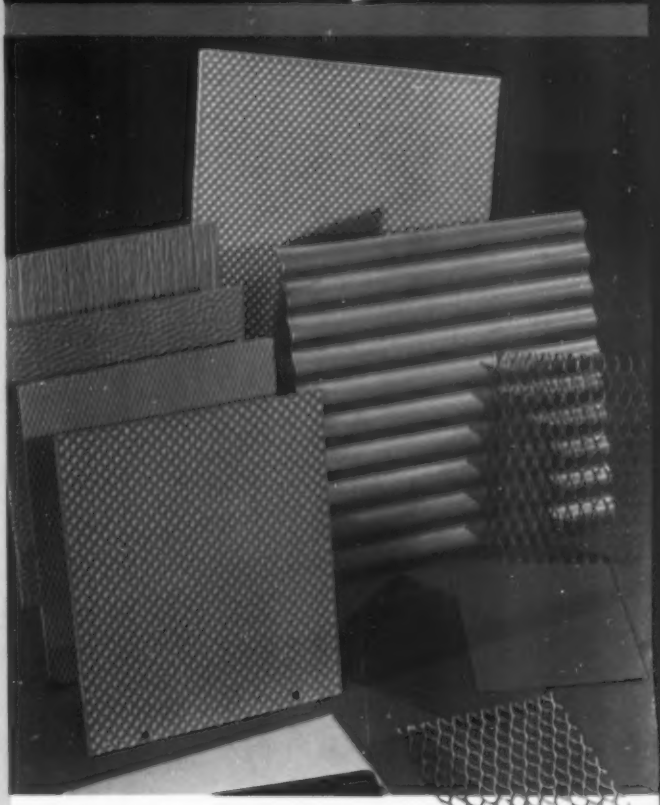
Different patterns require different coloring processes and these vary in the size and shape they can cover. They also vary in how accurately they register, and in the texture produced. Some processes get by with single firing. Others require multiple firings and this means additional bracing or a heavier metal base needed to combat the distortion. Some processes cover the base metal in a single coat, others need additional coats. Each coat adds to the total thickness, making it more brittle and subject to fracture when deformed. On the facing page is a chart showing the various decorating processes – comparing the finish each gives and its advantages and limitations.

There are various lusters, which include: Glossy – offers a smooth surface with low friction, ease of cleaning, high reflection, and a high sheen; semi-mat finish (satin) – reduces glare and other objectionable reflections; full-mat – provides some friction to give a nonskid surface. This full-mat finish should only be considered for special purposes because it tends to retain dirt and stains, and is less resistant to attack by the weather. Recently introduced are the metallic lusters such as gold, copper, bronze and gun-metal, and a whole spectrum of luminescent porcelain enamels now under development is expected to appear shortly.

Color combined with versatile engineering properties is one reason why porcelain enamels are forging ahead in industrial and consumer fields. Now you can get patterns simulating wood grain, leather, marble – also speckled colors and textures – without sacrificing the decorative enamel's inherent properties:

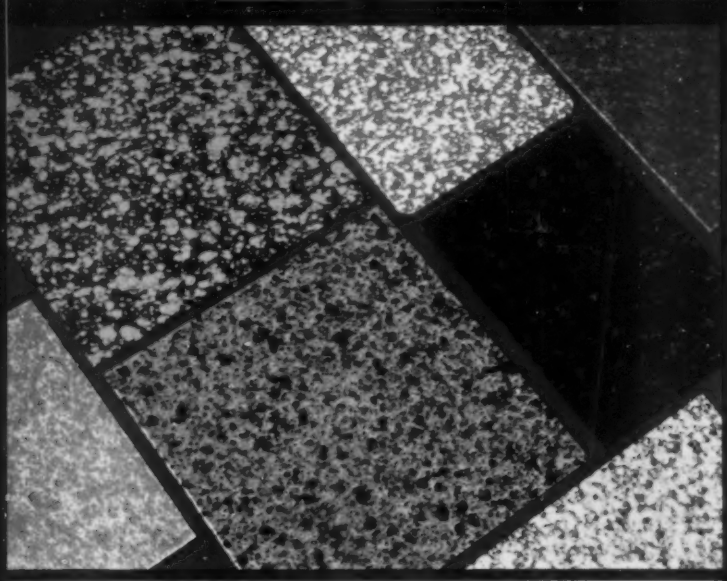
Chemical resistance – to attack by organic solvents, chemicals, gases, warm mild alkalis, and water. Available also are grades immune to most acids, including sulfuric and nitric. The familiar hot water tank with its glass lining – a porcelain enamel – illustrates one type of long-lasting corrosion resistance.

Heat resistance – porcelain enamels can stand brief exposures to 1500 F, intermittent exposures to 1100 F. For continuous service, temperatures should not exceed 750 F. They also have high ther-



Textures on metals . . .
break up glare from glossy porcelain enamels without sacrificing stain resistance or cleanability.

Speckling adds gold . . . as second color upon steel. The gold enamel is scraped off stiff brush onto fired background coat.



Stone-like face is given steel by spraying one or more colors at an angle onto a dry enamel background. All these polytone colors are then fired together.

Print becomes permanent . . . on these labels, instructions and dials, when letters or decal transfers are fired into porcelain enamel.

mal emissivity, and thermal-shock resistance that withstands sudden temperature drops. Special ceramic coatings (high-fired porcelain enamels) can protect metals up to 2000 F, and sudden freezing temperatures have no harmful effects. Although these special coatings are limited to the more conservative colors of green, gray or black, appearance here is secondary because parts at these temperatures should be shielded.

Physical properties – because they are hard as glass, the porcelain enamels are abrasion-resistant. This, combined with low coefficient of friction, gives a smooth, nonwearing surface. Some newer coatings developed for aluminum also promise to permit modest post-forming.

Electrical properties – nonconducting porcelain enamels are good insulators. They also serve as resistant films. Some of these enamels have electrical resistances ranging from 100 to 300 ohms per mil. Insulating properties decrease with rising temperature but are still useful up to 500 F.

Color permanence – the nonfading and nonstaining porcelain enamels retain their attractiveness as a decorative coating. There is now a full range of colors including pastels and dark, rich tones.

EDITOR'S NOTE: Additional articles on porcelain enamels and other high-temperature coatings for steel parts:

"Porcelain Coatings on Steel," Feb 17 '58, p 75 — new low-temperature enamels and better process control now permit one-coat porcelain for cold-rolled steel; gives basic facts on porcelain coating to simplify design.

"High-temperature Coatings," Jan 20 '58, p 61 — basic factors influencing choice of coatings for high-temperature resistance to corrosion and erosion.

"Hot-dipped Aluminum Coatings," Oct 28 '57, p 57 — how to substitute less costly base metals, lower fabricating costs and reduce maintenance by applying latest aluminum dipping techniques.

HOW MANY PLANETS IN AN EPICYCLIC GEAR?

Here's fast solution to the first phase—knowing the maximum number of branches—when making an epicyclic-gear feasibility study. It speeds up design of the desired gear system.

R J WILLIS JR, *Lightweight-gear Application Engineer, General Electric Co*

Designing a planetary or star gear system need not get bogged down in the first phase—determining the maximum number of planet gears that can be incorporated. Instead of tediously drawing separate layouts for each ratio trial, here is a faster approach that capitalizes on the geometry of simple planetary and star gears. The results can be plotted for convenience and reference.

Advantages are obvious, especially when a specification only defines the over-all ratio between input and output shafts, and some given center distance between these shafts are known. Obvious method of solution: Check to see if some form of offset gearing will satisfy the application. If the over-all ratio is large and the center distance small, offset gearing may not work and epicyclic gearing in series with the driven gear of the offset system is a logical approach.

System is more complex than straight offset gearing. Two basic building blocks are involved—the offset block and the epicyclic block. The optimum ratio split between the two basic gear arrangements that satisfy other design criteria should be known. This can be based on equal stress levels, by given envelope requirements—or as in aircraft gearing, by minimum weight.

The problem may be reduced to varying the ratio of the offset by equal increments and evaluating the complete gear system at each step. Varying the offset ratio, however, will change the epicyclic ratio based on the design requirements.

As the ratio of the epicyclic gear is varied its geometry is altered—proportions of sun gear to ring gear change. As a result, the annulus between the sun pinion and ring gear varies. This not only changes the size of the planet gears for each ratio change, but also the number which can be fitted into the annulus. In turn, the tangential driving load is varied, which is reflected in root stress and scoring calculations. Hence, before any solution is possible, the number of planets possible in the epicyclic gear for each incremental change must be known.

The following method permits rapid feasibility studies of the epicyclic gears, thus reducing time and boredom to a minimum. For comparison, three separate methods of evaluation are derived, each considering more of the variables involved and consequently being more complex.

Branches Possible in an Epicyclic Gear

The simplest solution considers the circumference of the planetary action circle to be a straight line. The number of possible branches is given in terms of the over-all ratio—Eq (3) on page 59. However, the analysis ignores any clearance between the gears, the addendum of the gear teeth, or the fact that the planet action circle is in reality a circle. Also, the normal epicyclic gear has some reinforcement between the front and rear portion of the cage structure.

For design purposes, these discrepancies are handled by multiplying a factor of 0.8 or substracting 1 from the equation. Eqs (3a) and (3b) show the final result.

Branches in a star system can be similarly solved. The geometry analysis results in Eq (2), but the ratio of planet gear to sun pinion is $(M_s - 1)/2$ and Eq (3) becomes $N_b = \pi\,[(M_s + 1)/(M_s - 1)]$. To satisfy the star system for the unconsidered factors, the same discrepancy factor is used as for the planetary system.

From the above it is obvious that if the over-all planetary gear ratio is one greater than the over-all star gear ratio, then the number of branches are equal. Hence for the same number of branches the over-all ratio of the star gear is one less than that of a planetary gear.

If the arc length of the planet action circle is considered, the number of possible planets is now the circumference of the planet action circle, divided by the diameter of a planet gear, times the ratio of the planet action

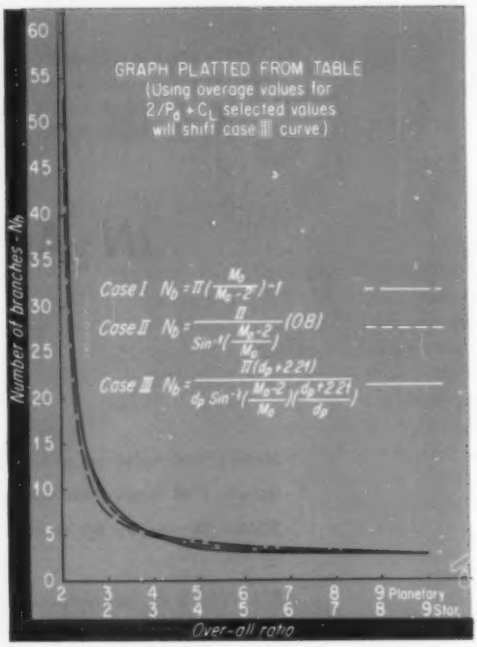
circle subtended arc length to its chord length. Eq (6) indicates the number of branches possible. As before, a factor must be applied to handle the unknown items, such as clearance, gear teeth addendum and others. Eqs (6a) and (6b) indicate final results.

When all variables are included that can affect the possible number of planet gears that can fit into the annulus formed by the sun pinion and ring gear, the final formula is Eq (10). Here, all factors have been included and there is no necessity for the addition of the discrepancy factor used in Case I and Case II.

Comparison of Results

Relationship among the three cases can be established by assuming $M_o = 4$ and $d_p = 3$. The number of branches using a 0.8 discrepancy factor is: Case I, 5.03; II, 4.80; III, 5.21. A factor of -1 gives: Case I, 5.28; II, 5.00; III, 5.21. It appears that a discrepancy factor of -1 gives closer and more consistent results. Actually, in constructing the graph from the Table, the numbers comprising the solution are rounded to the nearest whole number.

Star gear results, after changing formulas to use a value of $M_s = (M_o - 1)/2$, give similar results. Hence, the graph is applicable to both planetary and star gear systems–star system being one less in over-all ratio.



NOMENCLATURE

d_p = Pitch diameter of planet gear
d_s = Pitch diameter of sun pinion
d_r = Pitch diameter of ring gear
d_{pc} = Planetary action diameter $= d_s + d_p$
M_o = Over-all epicyclic ratio for planetary gear $= (d_r/d_s) + 1$
M_s = Ratio of planet gear to sun pinion $= d_p/d_s$
M_r = Ratio of ring gear to sun pinion $= d_r/d_s$
r_{pc} = Radius of planet action circle $= d_{pc}/2 = (d_s + d_p)/2$
C_{pc} = Circumference of planet action circle $= \pi d_{pc} = 2\pi r_{pc}$

Based on the geometry of sketch in Case I and the nomenclature, the following equations are apparent.

$$M_o = (d_r/d_s) + 1 \quad (A)$$
$$d_p = d_s M_s \quad (B)$$
$$d_r = d_s + 2d_p \quad (C)$$
$$d_r/d_s = M_o - 1 \quad (D)$$
$$d_r = d_s(M_o - 1) \quad (E)$$

Equating like terms, Eqs (C) and (E)

$$d_s + 2d_p = d_s(M_o - 1) \quad (F)$$

Substituting Eq (B) into Eq (F)

$$d_s + 2d_s M_s = d_s(M_o - 1) \quad (G)$$

Solving for M_s and clearing terms

$$M_s = (M_o - 2)/2 \quad (H)$$

Based on the geometry of sketch in Case II and the nomenclature, the following equations are apparent.

$$\text{Sin } \beta = (d_p/2)/(1/r_{pc}) \quad (J)$$
$$C = r_{pc}\alpha \quad (K)$$

Ratio of arc length subtended to its chord length is X

$$X = C/d_p$$

Substituting for C in Eq (L)

$$X = \alpha r_{pc}/d_p = 2\beta r_{pc}/d_p \quad (M)$$

Substituting for $2r_{pc}$ and $d_p/M_s = d_s$

$$X = [(d_p/M_s) + d_p]\beta/d_p \quad (N)$$

Substituting Eq (H) for M_s

$$X = [M_o/(M_o - 2)]\beta \quad (P)$$

Substituting into Eq (J) for $2r_{pc}$

$$\text{Sin } \beta = d_p/(d_s + d_p) = d_p/[(d_p/M_s) + d_p] = M_s/1 + M_s \quad (Q)$$

Substituting Eq (H) for M_s

$$\text{Sin } \beta = (M_o - 2)/M_o,$$

or

$$\beta = \sin^{-1}(M_o - 2)/M_o \quad (R)$$

Therefore, substituting Eq (R) into Eq (P)

$$X = (M_o/M_o - 2)\sin^{-1}(M_o - 2/M_o) \quad (S)$$

Based on the geometry of sketch in Case III and the nomenclature, the following equations are apparent.

Ratio of arc length to chord length is

$$X = 2r_{pc}\beta/[d_p + (2/P_d) + C_L] \quad (T)$$
$$\text{Sin } \beta = [d_p + (2/P_d) + C_L]/2r_{pc} \quad (U)$$

Substituting $(d_p + d_s)$ for $2r_{pc}$ and d_p/M_s for d_s

$$\text{Sin } \beta = d_p + [(2/P_d) + C_L]/(d_p/M_s) + d_p = [d_p/(d_p/M_s) + d_p] + [(2/P_d) + C_L]/(d_p/M_s) + d_p = 1/(1/M_s + d_p) + M_s[(2/P_d) + C_L]/d_p(M_s + 1) \quad (V)$$

Substituting Eq (H) for M_s

$$= (M_o - 2)/M_o + (M_o - 2)[(2/P_d) + C_L]/M_o d_p = (M_o - 2)[d_p + (2/P_d) + C_L]/M_o d_p \quad (W)$$

Solving for

$$\beta = \sin^{-1}(M_o - 2)[d_p + (2/P_d) + C_L]/M_o d_p \quad (Y)$$

Substituting $d_p(M_o/M_o - 2)$ for $2r_{pc}$ and Eq (Y) for β

$$X = \frac{d_p\left(\frac{M_o}{M_o - 2}\right)\sin^{-1}\left(\frac{M_o - 2}{M_o}\right)\left(\frac{d_p + 2/P_d + C_L}{d_p}\right)}{d_p + 2/P_d + C_L} \quad (Z)$$

BRANCHES POSSIBLE IN AN EPICYCLIC GEAR

M_o	CASE I			CASE II			CASE III
	From Eq (3)	From Eq (3a)	From Eq (3b)	From Eq (6)	From Eq (6a)	From Eq (6b)	From Eq (10)
2.1	65.97	64.97	52.78	65.86	64.86	52.69	65.92
2.2	34.56	33.56	27.65	34.50	33.50	27.60	34.41
2.3	24.08	23.08	19.27	24.00	23.00	19.20	23.86
2.4	18.85	17.85	15.08	18.75	17.75	15.00	18.26
2.5	15.71	14.71	12.56	15.61	14.61	12.48	14.93
3	9.42	8.42	7.54	9.25	8.25	7.40	8.84
4	6.28	5.28	5.03	6.00	5.00	4.80	5.19
5	5.23	4.23	4.19	4.88	3.88	3.91	3.38
6	4.71	3.71	3.77	4.31	3.31	3.44	3.15
7	4.4	3.4	3.52	3.95	2.95	3.16	3.00
8	4.2	3.2	3.35	3.71	2.71	2.96	2.99
9	4.04	3.04	3.23	3.53	2.53	2.82	2.83
10	3.93	2.93	3.14	3.39	2.39	2.71	2.77

EDITOR'S NOTE: Epicyclic gear studies have been a continuing subject of coverage in these pages. Listed below are relevant articles concerning problems met in calculations, selection, and application:

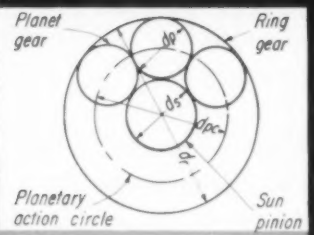
"Epicyclic Gear Train Calculations," Apr '57, p 186—step-by-step computation finds forces and speeds by reducing the train to its component parts and analyzing the center member.

"Epicyclic Gears for Control Mechanisms," Feb '57, p 194,—method of applying and calculating 2-gear epicyclic system to control mechanisms.

"Stress Cycles in Planetary Gears", Jan '57, p 219, tabulates formulas for finding the number of stress cycles a gear tooth receives during its life.

"Formula for Epicyclic Gear Train of Large Reduction," Mid-Oct '57, p E12, shows configuration and calculations for a reduction of 500:1 or greater.

"General Equations for Solving All Planetary Gear Ratios," Mid-Oct 55, p E12a, indicates that the solutions for all gear train arrangements are derived with only a few variations, from one basic general equation.



CASE I

Circumference of planetary action circle is assumed to be a straight line of length $\pi(d_s + d_p)$. Hence, the number of branches is:

$$N_b = \pi(d_s + d_p)/d_p \quad (1)$$

Substituting Eq (B) into Eq (1)

$$N_b = \pi(d_s + d_s M_s)/d_s M_s, \text{ or}$$

$$N_b = \pi(1 + M_s)/M_s \quad (2)$$

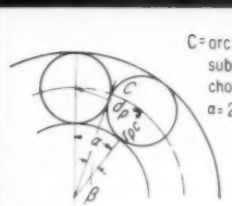
Above result is an equation in terms of the planet gear to the sun pinion. Substituting Eq (H) for M_s gives the number of branches possible in terms of the over-all ratio, which is normally known:

$$N_b = \frac{\pi[1 + (M_o - 2/2)]}{(M_o - 2/2)}, \text{ or}$$

$$N_b = \pi M_o/M_o - 2 \quad (3)$$

$$N_b = \pi(M_o/M_o - 2) - 1 \quad (3a)$$

$$N_b = 0.8\pi(M_o/M_o - 2) \quad (3b)$$



CASE II

Circumference of the planet action circle (C_{pc}) is made up of a number of arc lengths (C) which subtend chord lengths equal to the planet gear diameter (d_p). The number of branches possible is then the circumference of the planet action circle divided by the arc length (C). The ratio of arc length to chord length is designated by (X) which is equal to (C/d_p). Hence, the number of branches possible is:

$$N_b = \frac{C_{pc}}{C} = \frac{C_{pc}}{d_p X} \quad (4)$$

Substituting for C_{pc} and X

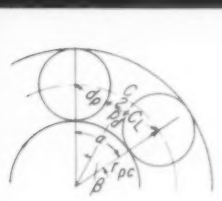
$$N_b = \frac{2\pi r_{pc}}{d_p[(M_o/M_o - 2)\sin^{-1}(M_o - 2/M_o)]} \quad (5)$$

Substituting $(d_s + d_p)$ for $2r_{pc}$, Eq (B) for d_p and Eq (H) for M_s

$$N_b = \pi/\sin^{-1}(M_o - 2/M_o) \quad (6)$$

$$N_b = [\pi/\sin^{-1}(M_o - 2/M_o)] - 1 \quad (6a)$$

$$N_b = 0.8[\pi/\sin^{-1}(M_o - 2/M_o)] \quad (6b)$$



CASE III

Same reasoning to account for arc length of subtended chord as used in Case II applies—except that depth of gear teeth and clearance between planet gears is added. This accounts for all of the variables that affect the number of planet gears possible.

$$N_b = C_{pc}/d_p X \quad (7)$$

Substituting for C_{pc} and X

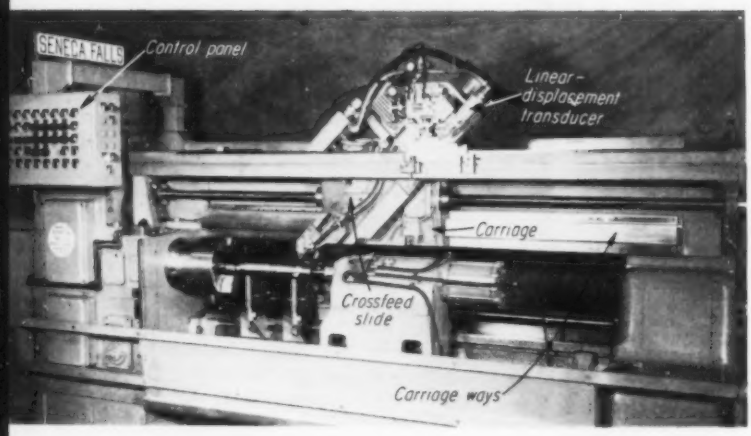
$$N_b = \frac{2\pi r_{pc}}{d_p\left[\dfrac{d_p\left(\dfrac{M_o}{M_o - 2}\right)\sin^{-1}\left[\dfrac{(M_o - 2)(d_p + 2/P_d + C_L)}{M_o d_p}\right]}{d_p + 2/P_d + C_L}\right]} \quad (8)$$

For power transmission gearing P_d normally varies from 7 to 15, therefore $2/P_d$ varies from 0.2857 to 0.1333. If blocks are used in the cage structure, C_L varies from 1 to 3 in. Therefore

$$[(2/P_d) + C_L] \text{ avg} = 2.21 \quad (9)$$

Substituting $(d_s + d_p)$ for $2r_{pc}$ Eq (B) for d_p, Eq (H) for M_s, and Eq (9) in Eq (8)

$$N_b = \pi(d_p + 2.21)/d_p \sin^{-1}[(M_o - 2/M_o)(d_p + 2.21/d_p)] \quad (10)$$



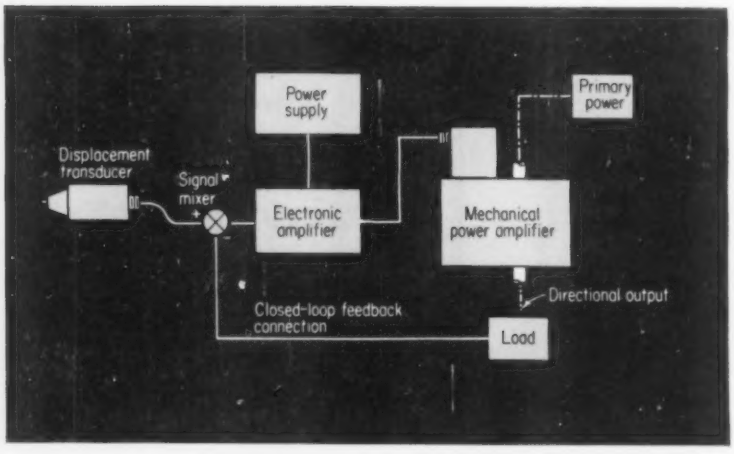
Carriage travel . . .
is controlled by automatic comparison of voltages from two potentiometers. One, located on the control panel, is set by a dial calibrated in inches of desired carriage travel. The other rides the carriage and its voltage output is a function of actual carriage position. Both potentiometers are interconnected, with a continuous comparison made of output voltage of each. These voltages are equal only when carriage position corresponds to dial setting. Whenever the actual and desired positions do not correspond, the carriage is automatically driven to the "null point" where carriage position and dial setting agree.

Actual movement of the carriage is controlled by clutches actuated by voltage phase. Positive phase actuates the forward clutch; negative phase the reverse clutch.

MACHINE TOOL with SENSE of TOUCH

Here is a lathe that has not overlooked aids to automatic operation. The carriage is worked by a pair of potentiometers . . . a templet-controlled mechanical amplifier controls direction and speed of the cross slide.

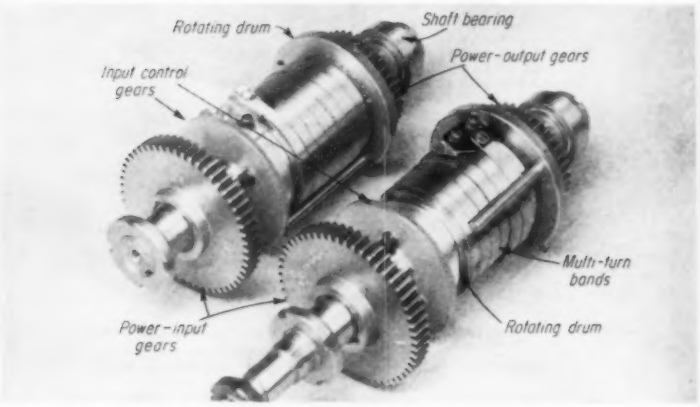
Particularly adaptable to small-lot production and rapid setting up, this control system is also simple enough to minimize maintenance and adjustment. The Model LQ automatic lathe is produced by Seneca Falls Machine Co, Seneca Falls, NY.

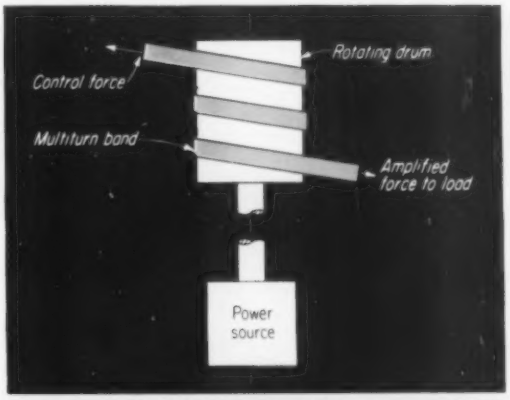


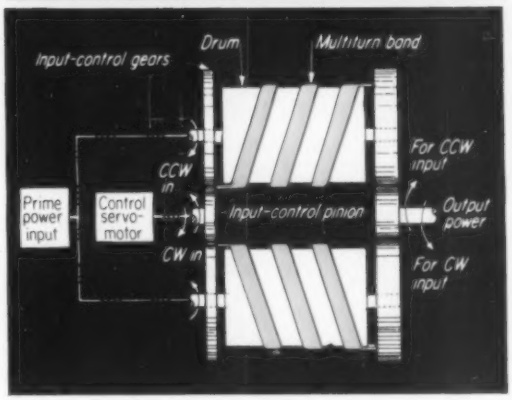
Closed-loop system . . .
shown in block diagram is used for crossfeed-slide control. Signals from the displacement transducer pass through signal mixer and electronic amplifier to the servomotor in the mechanical amplifier. The power supply is used to generate dc voltage for the electronic amplifier and servomotor. A 3-phase motor supplies constant-speed power to the mechanical amplifier where the 2-phase dc induction servomotor controls direction and quantity of final output. A feedback connection originates from a tachometer generator coupled to the servomotor.

Primary feedback control is result of mounting displacement transducer housing on the crossfeed slide, with transducer core moved by templet.

IN NEW PRODUCTS



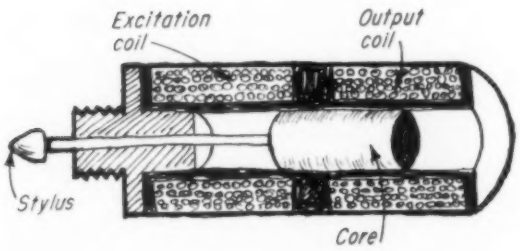


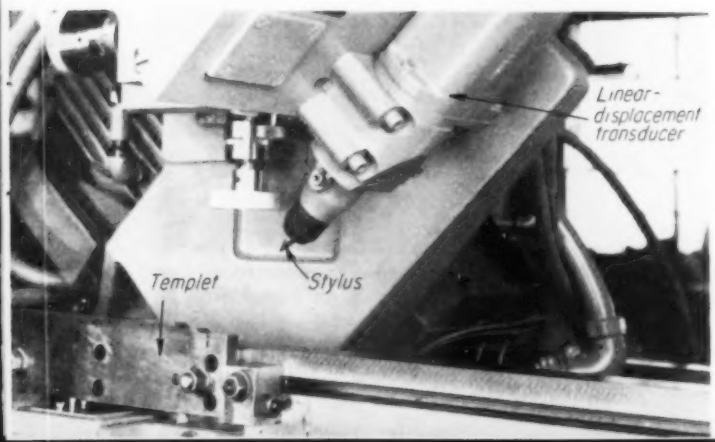


Mechanical power amplifier . . .
that drives crossfeed slide uses the principle of the windlass. By varying the control force, all or any part of power to the drum can be utilized.

Two drums mounted back to back supply the bi-directional power needed in servo systems. Replacing the operator with a 2-phase induction servomotor permits using electronic or magnetic signal amplification. A rotating input avoids linear input and output of the simple windlass. Control and output ends of the multiturn bands are both connected to gears mounted concentrically with the drum axis.

When servomotor rotates the control gear it locks the band-drum combination, forcing output gear to rotate with it. Clockwise rotation of the servomotor produces CW power output while second drum idles. Varying the servo speed, by changing servo voltage, varies output speed.





Templet control . . .
governs movement of the cross slide and cutting tools. After amplification, signals from a linear-differential transducer are fed to a servomotor whose output is amplified by the mechanical power amplifier. This amplifier advances or retracts the cross slide and cutting tools mounted on it. Since the cross slide is positioned by a self-locking nut-screw drive, amplifier only operates during contour changes.

The transducer is a transformer whose output signals vary in magnitude and phase with magnitude and direction of templet contour change. Excitation and output windings in the transformer are coupled by the movable core.

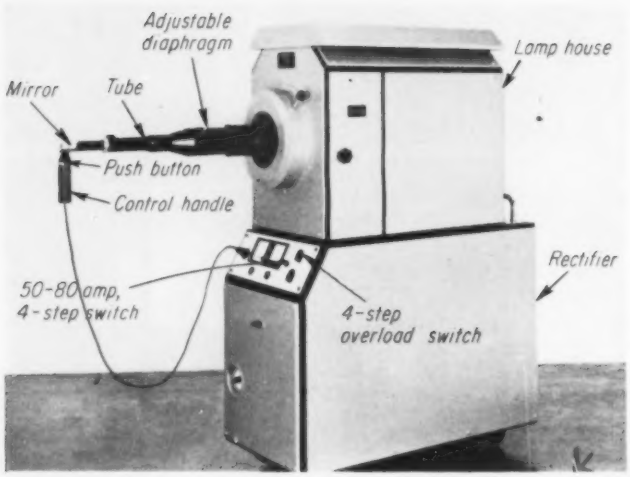
The core and its stylus are spring-loaded to project from the transformer housing. Resulting signal moves the slide toward the templet. When stylus contacts templet the core is forced into the transformer housing. This decreases the voltage until a null point is reached. Magnitude and phase of output voltage are proportioned to displacement and direction of displacement from this null point.

This system normally operates with a constant distance between stylus tip and cutting tool. Varying this distance by small amounts allows undersize or oversize parts to be produced from the same templet. This feature can compensate for tool wear or produce oversize parts for final machining operations.

LIGHT Replaces Heating Instrument

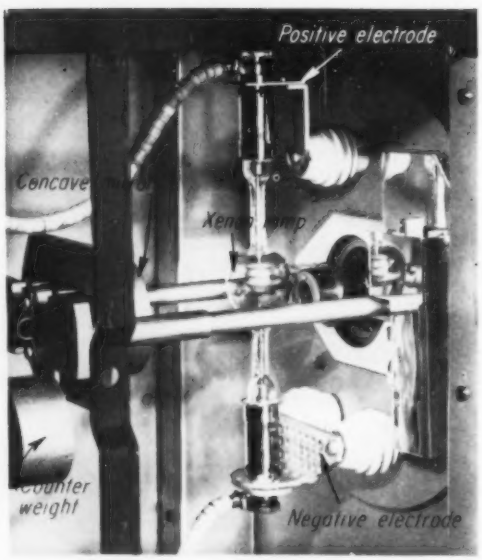
Another familiar phenomenon is turned into a delicate tool—now for optical surgery. Light from this machine is concentrated and directed into the human eye where it substitutes for a cauterizing electric needle.

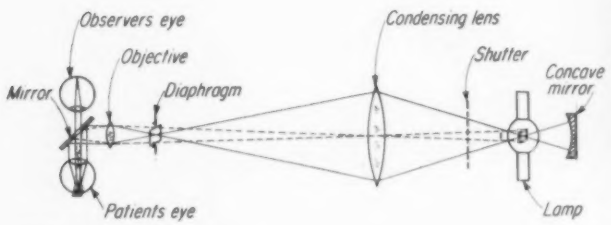
The method grew out of research by German opthalmologist Gerd Meyer-Schwickerath into why retinal burns were suffered by people who watched eclipses with the naked eye. His technique focuses light, six times more intense than that from the sun, into the eye. The machine was developed in conjunction with Dr. H. Littman of Carl Zeiss Works, Oberkocher, W. Germany. Its use: to "weld" a detached retina. Source of the light is the arc from a high-pressure-gas discharge in a xenon lamp.



Light source . . .
is xenon lamp within the lamphouse. From there, light travels through tube that swivelling arm can move in any direction. Push button on the handle actuates a shutter mounted between the lamp and optical system. Opening the shutter lets high-intensity light through and—in the overload range—simultaneously subjects the lamp to an overload.

Intensity can be controlled in eight steps: First by a 4-step switch for lamp loadings of 50 to 80 amps; then by a second 4-step switch providing overloads up to 120 amps. Intermediate adjustment is provided by an adjustable diaphragm.

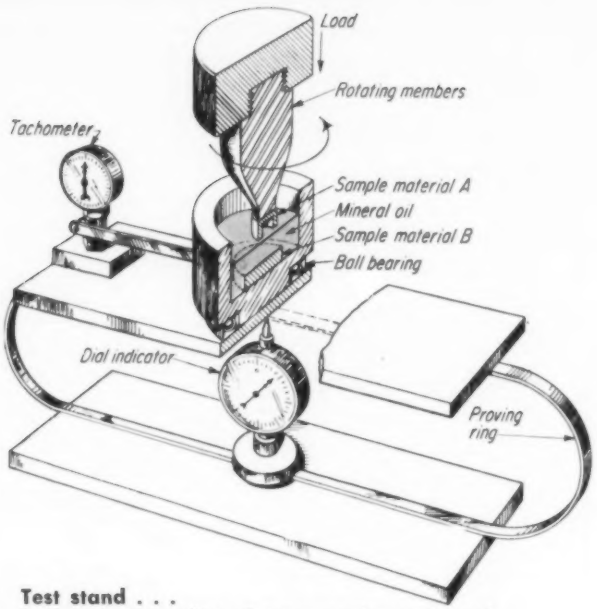




Concave mirror . . .
increases intensity of the light source 70% by reflecting the image of the lamp back upon itself. Light path is through shutter, condensing-lens diaphragm and objective lens to a rotatable opthalmoscope mirror. A 12 mm-dia image of the condenser is formed in the plane of the patient's pupil. Final focus ot the light source is on the fundus, or base, of the patient's eye—resulting heat provides cauterization.

The operator looks through a hole in center of the mirror, which is mounted on the control handle, to regulate location of the light. The push button-operated shutter alters brightness in the ratio of 1:50 or 1:100 for observation or cauterization.

Brackets for the xenon lamp and concave mirror mount on universal carrier at front of lamphouse. Counterweight on mirror bracket balances weight of tube and control handle.



Test stand . . .
for investigating galling. Rotating member is clamped to spindle of milling machine. Load on samples is measured by noting deflection of the proving ring as recorded on dial indicator.

more surface polishing... less GALLING

Of many factors that inhibit galling of metals, the most important is a preconditioned surface. Here are test results showing why components should be "worn-in" before they take loads, and why cast irons are less likely to gall than the steels or brasses.

WILLIAM H MOORE, *General Manager*
Meehanite Metal Corp

THIS IS GALLING

When metals are in sliding contact, friction may cause particles from one surface to adhere to the other. The resulting tearing action that damages one or both surfaces is called **Galling.**

If galling is severe the two adjacent surfaces may actually weld together. This is **Seizing.** When the weld is broken and part of one surface adheres to the other, it's called **Pick-up.** Ordinary chipping or fragmenting is **Scuffing.** When portions removed from a surface cause only scratching and light gouging, **Scoring** occurs. Thus, galling comes in several degrees.

Its main cause is believed to be instability of atoms or molecules on a metal surface. Linked to their neighbors on three sides only, they retain a strong capacity to combine on the fourth side—explaining the adherence between two such surfaces.

It is still something of a puzzle just why metal surfaces sliding against each other show a tendency to gall. But both the tendency and the harm it does can now be reduced. We know more about taking advantage of preconditioning—"wearing-in" the surface of a component before subjecting it to friction under high loads.

This wearing-in causes the surface to flow and become amorphous—the so-called Beilby layer. Because the new surface has a higher polish and lacks crystallinity, it has less tendency to combine with another surface. Presence of the Beilby layer will reduce the friction coefficient below that usually regarded as critical in galling.

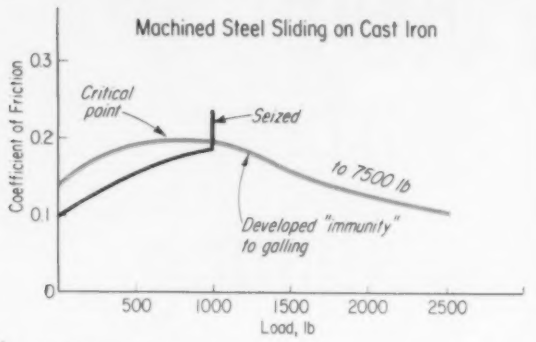
Other factors that influence galling are the initial coefficient of friction, machined condition of the surfaces, type of lubricant, hardness of the surface, and density of the material.

CHANGES IN FRICTIONAL RESISTANCE

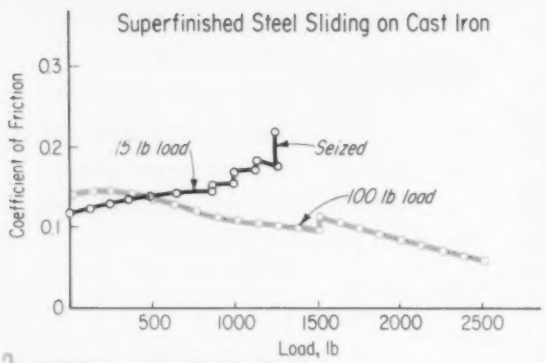
The coefficient of friction usually changes as the surfaces wear-in. To investigate this and other factors relating to galling, a series of tests with steels sliding on cast iron were conducted in a bath of mineral oil. The load during the test was increased in increments until a sharp increase in frictional resistance indicated seizing. The curves resulting from the tests are shown on next page.

In a typical test run, Fig. 1, one of the combinations developed a Beilby layer, causing a reduced coefficient of friction—frictional resistance climbed as the load increased, then dropped, indicating the critical period had passed. The second combination seized because it failed to develop a Beilby layer.

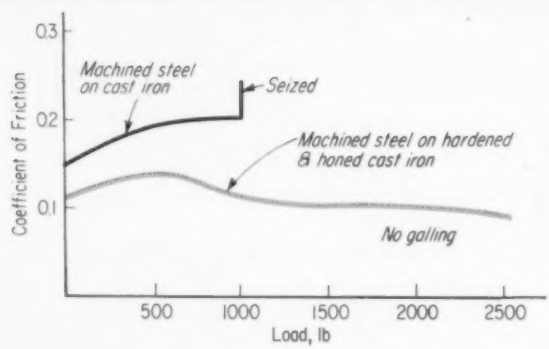
(Continued next page)



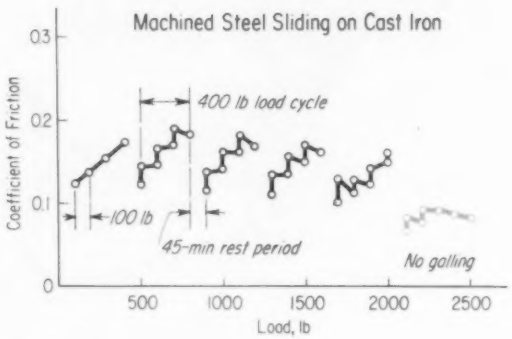
1 **In these two tests . . .**
one combination galled rapidly until parts seized; second combination developed protective Beilby layer, as indicated by drop in friction resistance.



3 **Polishing superfinished steel . . .**
with heavy load (100 lb) caused surface to "flow," thus developing gall resistance.



TESTS SHOW PREVENTIVES FOR GALLING



2 **Results of "wearing in" . . .**
parts to develop gall immunity. Load was applied in 100-lb increments with 45-min. rest after every 400-lb cycle.

4 **Lower friction torque . . .**
of cast-iron (Meehanite GA) combination indicates reduced likelihood of galling.

5 **Heat-treated cast iron . . .**
shows definite resistance to galling as compared with ordinary cast iron.

Seizing seldom occurred where the coefficient was below 0.15—but it was almost certain when the coefficient exceeded 0.20.

INFLUENCE OF SURFACE FINISH

A metal with a coarse finish has a higher tendency to gall than one with a fine finish because it requires a longer wearing-in period to produce an effective Beilby layer. Machine marks, drags, cuts, scratches and surface inequalities are all potential causes of galling trouble. On the other hand, a dense cast iron with good machinability and ability to take a high polish is an important first step toward avoiding trouble.

It is difficult to measure the exact effect of surface

finish on galling resistance. As metal parts move against each other the surface finish keeps changing so that initial surface finish may have very little meaning. Rough surfaces will have a higher initial coefficient of friction, but will also tend to abrade more quickly, thereby exhibiting a rapid change in friction resistance. Here are the results from tests using three degrees of finish in the rotating member.

Surface Condition	Finish, microin.	Seizing Load, lb
Machined	65	1000
Ground	12	Did not seize at 2500
Lapped	8	Did not seize at 2500

These tests show a machined surface is more likely to seize than one finished to a higher degree by grinding or lapping.

PRECONDITIONED SURFACES

Machined surfaces can be made non-galling by exposing them to a series of "wearing-in" loads—loads that are below the final operating load.

For example, in Fig. 2, where the mating members are machined steel and cast iron, a 400-lb load cycle was applied in increments of 100 lb—one per minute—with a 45-minute rest period between cycles. The rise in the coefficient of friction was less pronounced with each successive cycle until the surfaces were adequately worn-in, as indicated by the continued low coefficient of friction at 2500 lb. Steel surface changed from 60 down to 7 microin., whereas the cast iron changed from 80 to 60 microin. Thus the softer material tends to flow more readily and assumes a worn-in condition first.

Also, a fine surface finish requires less wearing-in—the reason why it is important to work toward finer finishes, such as those produced by honing. As a rough rule, a material having a finish of 12 microin. or less will not require a careful wearing-in period.

For example, a superfinished surface having a finish of 2 microin, was produced with a relatively light polishing load of 15 lb in one case and a heavier load of 100 lb in the second case. Metals finished with the heavier load, Fig. 3, did not seize because polishing load produced a Beilby layer.

EFFECT OF LUBRICATION

As long as a proper fluid film of lubricant separates the wearing parts, harm from seizure, wear or scratching is unlikely. However, there exists quite a difference in the ability of metal surfaces to absorb and hold on to the lubricant. Although this may be an inherent function of the metal itself, it most likely results from the fabricating techniques.

A cast iron has a "graphoid" layer on the surface which normally becomes covered with an oil film, but if this film should become ruptured, the layer itself may substitute as a lubricant. This is why a cast iron can run "dry" for short periods without seizure.

Lubricating oils may vary considerably in ability to provide adequate boundary lubrication. Additives can increase the proportion of oleic acid to mineral oil, and thereby definitely decrease the coefficient of friction—in turn reducing the likelihood of galling. And fatty acids such as stearic acid and palmitic acid provide extra protection against high friction, because they tend to give a lubricating layer several molecules thick. It has also been noted that such chemicals as tricresyl phosphate, dibenzyl disulphide and triphenyl arsine will improve boundary lubrication. Many commercial lubrication oils contain specific additives that will make them behave favorably from a galling standpoint.

COMPARISON OF MATERIALS

Using load increments of 100 lb per min and machined steel as the rotating member, these values were established as an average of three tests with four other metals:

Material	Seizing Load, lb
Meehanite, type GA	1300
Meehanite, type GE	1200
Graphitic cast iron	1000
Navy bronze	800

Thus, Meehanite, a dense cast iron, is less likely to seize than Navy bronze or graphitic cast iron. This conclusion has been substantiated by other tests conducted under slightly different conditions.

In general, however, it has been found that the proper condition of the surface of the metal has a far greater influence on galling resistance than does its composition or structure. As an example, one test indicated a lower frictional torque when GA Meehanite was substituted for the steel member, Fig. 4. Here, both surfaces were worn-in and the lower frictional torque was presumably caused by self-lubrication features of graphitic material.

EFFECT OF HEAT TREATMENT

Resistance to galling can also be increased by heat treatment. In tests a hardened and honed material exhibited a low coefficient of friction at all loads, Fig. 5. It might be argued that the surface finish resulting from honing is responsible for this improved behavior, but it has been found in practice that heat treatment definitely improves galling resistance.

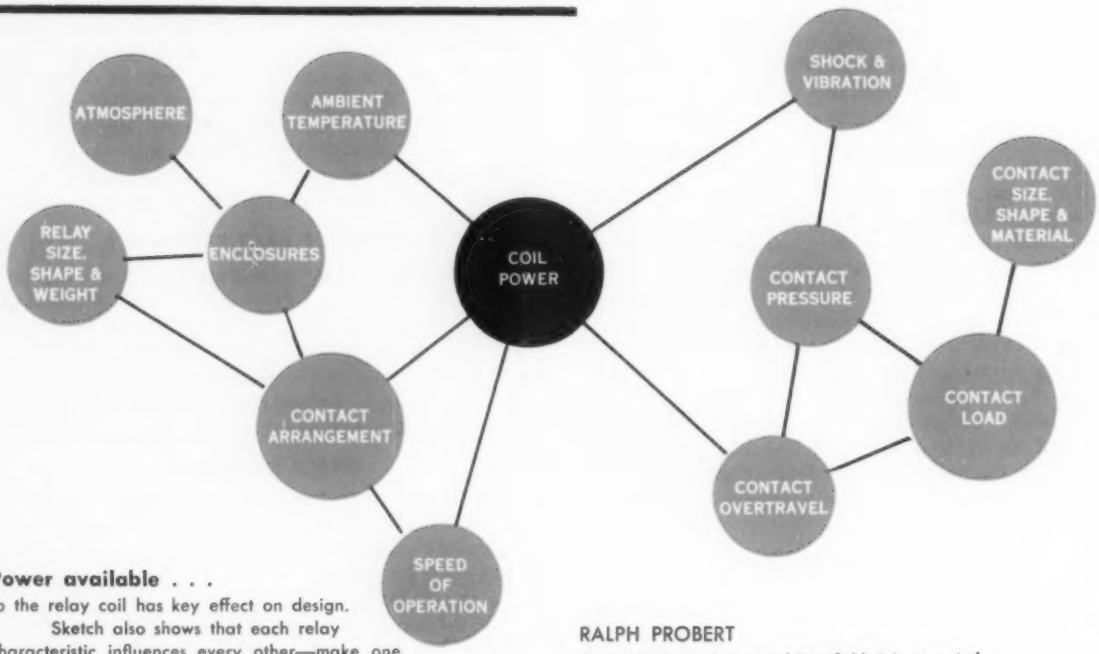
EFFECT OF DENSITY

Metals that have high density (a specific gravity of 7.15 to 7.4) and uniform distribution of graphite in an all-pearlitic matrix have a low tendency to gall. With Meehanite, for instance, the uniform distribution pattern is obtained this way: the chemical composition is adjusted for average thickness sections as in cast-iron technology, but the charge of raw material is so selected with respect to graphite content that there will not be excessive graphite in the heavier casting sections.

Molten metal is then graphitized with alkaline earth metal combinations that produce the ultimate in graphite shape and pearlitic matrix, and adjust the carbide stability of the processed metal to give the required graphite content in the lighter-than-average sections. The net result is a structure and surface condition well suited to prevent galling and seizing.

EDITOR'S NOTE: See "New Coefficients Predict Wear of Metal Parts," June 23, p 71, for analysis of four different types of wear and how simple formulas employing wear coefficients, similar in versatility to friction coefficients, give answers that can lengthen life of a sliding system.

THIS MONEY-SAVING GUIDE TELLS HOW TO SIZE UP ELECTROMAGNETIC RELAYS



Power available . . . to the relay coil has key effect on design. Sketch also shows that each relay characteristic influences every other—make one change, and another may be necessary.

Technology has made tremendous strides with these electrical switching devices. But a relay able to switch 10 million times may be as unnecessary in many applications as it is expensive. And design will run into fewer troubles, too, when selection is made to fit an exact need.

RALPH PROBERT
Project Engineer, Potter and Brumfield, Princeton, Ind.

A zealous salesman sold a shipment of electrical relays to a manufacturer of garage-door openers. Design had planned for a relay that would operate once when the door opened and once when it closed. The door was guaranteed for five years, so the manufacturer said he wanted a relay with "long life." But long life, to the salesman, meant a million operations, and that's what he specified. Simple arithmetic shows that, to justify such a relay, the door would be opening and closing 26 times a day for 100 years.

That exemplifies how easy it is these days to over-specify relays. Technology can now provide relays that will outlive most appliances and electrical equipment

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Your Scorecard for Relays

The questions to consider when appraising a relay fall into the following 17 categories. They cover the specifications usually sufficient.

1—Contact arrangement. Single-pole single-throw? Double-pole double-throw? 6-pole double-throw?
2—Open-circuit voltage. Are wide contact gaps needed?
3—Load to be switched (for each circuit). A motor? Resistive load? Lamp? 1 amp or 10 amps? High surge of current at start?
4—Coil-actuating current. Ac or dc? Watts or milliwatts? Low or high frequency? Must coil carry max current continuously? What about overvoltage conditions?
5—Duty cycle. One operation a day? Or 60,000?
6—Life. 10,000 operations? 10,000,000?
7—Speed of response. Operate in 200 milliseconds—or 20? Release in 50—or 5? What about time delay?
8—Settings. Operate at 80 v and release at 40? Or operate at 10 v and release at 8?
9—Coil resistance. How much can be tolerated? 1 ohm? 1000?
10—Ambient temperature. Over 250 F? Less than 150?
11—Government and other requirements. Military specs? Underwriters Lab (U/L) specs? Joint Industry Conference (JIC)?
12—Atmospheric conditions. Humid? Dusty? Corrosive? Explosive? High-altitude?
13—Shock, vibration, acceleration. What are forces and directions? Are they applied a few times or continuously?
14—Size and shape. Must the relay be small?
15—Mounting. Brackets? Socket? Supported by wiring only?
16—Connector. Solder? Plug-in? Printed circuit? Threaded-terminal?
17—Physical protection. Will it be stood upon? Tampered with?

produced for consumer use. You can get a relay that will operate a million, or maybe even 100 million times. Or you can buy a sealed electromagnetic relay that will take a shock of 100 times gravity, and shocks of 30 g vibrating at a rate up to 2000 cps—yet it will operate perfectly 199,999 times out of 200,000. It can switch a current of up to 30 amp at 30 volts dc. You can store it at 480 F for five years. For special applications, such a relay is well worth the $35 apiece.

But when all those requirements are not absolutely necessary, a lower-cost relay will often handle the job just as well—if the specifications are gone over carefully with help from a relay engineer.

A good way to appraise relays is in terms of special versus standard. Answers to the questions listed in 17 categories on this page will often indicate that a stock relay can do the job.

Moreover, many relays designed for specific applications must sacrifice some virtues of a standard type. For example:

- A high-speed relay is less sensitive than a slow-speed one, and cannot have as many moving parts.
- A closely adjusted relay that "pulls in" and releases on small voltage or current differences does not perform well if ambient temperature varies widely.
- A heavy-duty power relay needs high contact pressures and cannot operate on a low current supply meant for a more sensitive relay.
- Hermetic sealing protects against unfavorable atmosphere but results in insulation deterioration that contaminates contacts.

Special relays can usually be made by modifying standard ones, but this raises the cost—often too high for the ordinary user. Yet when design demands unrealistic safety factors, such modifications become necessary. Relay manufacturers devote as much as 25% of plant space to these "specials."

THE RELAY'S MAIN JOB

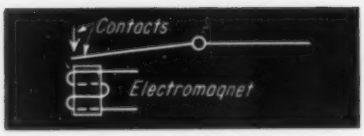
A relay switches circuits when instructed by a small controlling signal. This, the main job of a relay, is not always simple.

An inductive load, for example, generates an energy component greater than the normal load . . . and the contacts must be able to handle it. Lamp loads, though not inductive, are 10 times greater at start when filaments are cold than at steady-state hot condition when filament resistance has increased. Also, ac frequencies affect amount of arcing when the relay contacts open—and open-circuit potential requires sufficient contact gap to stop arcing.

Deposits on contacts interfere with their closing and significantly raise their resistance. High temperatures increase such deposits in hermetically sealed relays by driving volatile material out of organic coil insulation (outgassing). It becomes necessary to increase overtravel (distance the contacts travel after the actuating armature comes to rest) to build up contact pressure and penetrate the deposits. "Wipe" (sliding movement of the contacts against each other) also increases with overtravel, and helps the penetrating action. However, limits for contact pressure must be specified if millions of operations are required—contact wear is usually greater at higher pressure. One answer if troublesome outgassing is expected is to hermetically seal the contacts from the coil. This increases cost. Another answer is to provide some absorbing medium—such as a cube of activated carbon—to collect the gases. But a point can always be reached where no satisfactory compromise exists . . . in such cases, high cost or frequent replacement are the result.

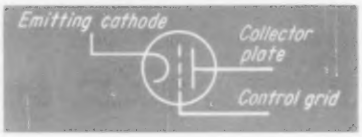
Shock and vibration make higher switching forces

Electromagnetic vs Other Types

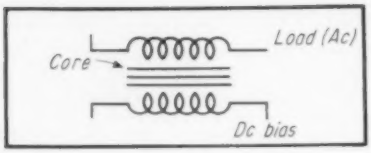


The electromagnetic relay is the oldest, most common device for switching circuits. Its one or more sets of moving contacts are actuated by the plunger or plate of an electromagnetic. Years of use have proven it reliable—and its operating life can be predicted. It is simple, well-understood, and low in cost.

Many other relay types are available, however, and some may soon be as common as the electromagnetic. But all manufacturers of relays, regardless of the type they make, agree no categories will become obsolete in the foreseeable future. Even highly transistorized circuits will usually have an electromagnetic relay designed-in at the output to do the hard work. What are these other types?

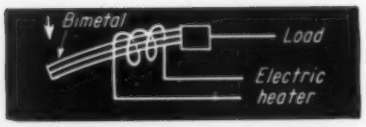


Electronic tubes are common for switching power circuits, as well as other jobs such as amplifying current or voltage. For example, thyratrons, ignitrons and other controlled rectifiers conduct current when triggered, performing a relaying function. They are dependable, can carry large currents, and have reasonably long life. High triggering signals—over 50 v—are usually required.

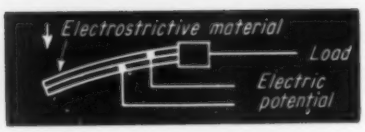


Magnetic amplifiers, although usually thought of for controlling rather than just switching, can function as ac relays if the triggering signal drives the output from essentially zero to full current. Amplifiers of this type are sometimes called "switching reactors," and are usually higher cost than ordinary relays. The transformer-type construction has no moving parts, controls current output by varying magnetic characteristics of core. Higher operating speeds are therefore possible. Life can be unlimited because there is no wear. Sizes from miniature up to 200 hp are being made now—larger are feasible.

New solid-state switching devices, made from semiconductor materials such as silicon and germanium, have already invaded the relay field. They work because their ability to conduct current can be increased from practically zero to relatively high values by small triggering signals at a control point. And because of zero physical inertia (no moving parts), and very little electrical capacitance, the switching speeds are extremely fast—measured in microseconds or less. Transistors and switching diodes are two examples. Transistors—designed primarily to control current rather than merely switch it on or off—are usually limited to low-power signalling and control applications. Switching diodes carry much heavier loads . . . up to 50 amp. Both types must be kept cool or they will break down and lose their ability to shut off current.



Thermally operated mechanical relays (with bimetal actuators that bend with heat to move the contacts) are available. An electrical signal current through the heater coil warms the bimetal element. Some time delay occurs while element is absorbing the heat.



Electrostrictive relays are similar in mechanical action to bimetal type—relative expansion between the two materials (only one is metal) bends actuator to move contacts. Difference is the nonmetal half is made sensitive to the electrical field rather than to heat, and it shortens in dimension when a signal voltage is impressed on it.

necessary. These forces—generated by coil power—affect contact pressure, contact bounce and speed of operation.

THE POWER SUPPLY

Any relay actuator—the assembly of electrical and magnetic parts that open and close the contacts—needs power. With adequate margin of power, the relay can compensate for many borderline specifications. It gives extra shock and vibration resistance, allows greater contact gaps, speeds operation, and makes self-cleaning action of contacts more positive.

Full knowledge of the power supply is essential to proper application and will often enable the supplier to recommend a standard relay. Dc is usually better where available—even if rectifiers must be added to the relay or system. Choosing ac will require knowing if the signal to the relay coil has a standard or random frequency, and if it has a normal or unusual waveform. The relay engineer can check on this from a circuit diagram. Different power-supply characteristics account for a large number of the over 20,000 variations of electromagnetic relays available from one manufacturer alone.

An extremely sensitive relay needs less actuating power, but costs more. And the lack of surplus power reduces ability of the relay to operate under less-than-ideal conditions.

The circuitry in which the relay must function is also important. For instance, how much relay-coil resistance can be tolerated and what other components, if any, will be used in the same circuit? And are these

components compatible electrically, mechanically and thermally with the relay?

Voltage to operate or release should be specified as realistically as possible. A relay that operates on 10 v and releases at 8 can be expensive because the drop-out force will be only 20% less than the hold-in force. Considering tolerances on coil resistance, magnetic retentivity, airgap, finishes on moving parts, and so forth, it becomes an expensive time-consuming task to make and adjust such relays. Where possible, specify a very low drop-out—or let the relay engineer decide.

High-speed operation can be obtained by modifying standard relays, but is costly—low-speed is often suitable. A common example of an inexpensive, low-speed relay is the long-frame telephone-type . . . it can delay release time over ½ second.

Other variations on the well-known coil-armature-type actuator are available. Latching relays, for example, positively lock and hold at each position—either mechanically or magnetically. A stepping relay has one actuator that operates many separate contacts (or groups of contacts) in a sequence providing a new position for each signal to the actuator. A time-delay relay—with fluid or electrical damping—is also possible. No matter how unusual the design, answers in the 17 categories are sufficient guides to specifications.

MUST IT BE SMALL?

The demand for miniaturization has produced many new series of relays labelled midget, miniature, subminiature, microminiature and, most recently, transistor-size. There is an acute need for such relays in some weapons systems, computers, control systems, and in aircraft.

Yet none of these relays was designed to replace the heavy-duty power relay or the multiswitching telephone-type relay. There is not room enough in tiny relays for large contacts to carry heavy loads, nor can the contact airgaps be wide enough to withstand high dielectric breakdown voltages.

MILITARY OR INDUSTRIAL?

If the relay is for military applications or those requiring U/L approval, dig out applicable specifications. Many stock relays meet or exceed these requirements. Usually, however, more than one military specification must be satisfied. A relay may need to pass shock and vibration tests per Mil-R-5757-C as well as high-altitude dielectric breakdown test per Mil-R-6106-C.

If a second supplier is sought, don't copy exact specifications from another manufacturer's print unless the application is tailored exactly to this one particular relay. If a $\frac{1}{16}$ or $\frac{1}{8}$-in. size difference or a few ohms difference in coil resistance are tolerable, then use the old specifications as a guide to locate a second source—but not as an ironclad blueprint.

WILL TREATMENT BE BRUTAL?

Modern relays operate under conditions considered impossible 15 years ago and unheard of 20 years ago. They can be hurled against the ground at 6 miles/sec and still function afterwards. Vibration at 2000 cps with peak velocities of almost ¼ mile/sec—or continuous acceleration af about 2½ miles/sec²—do not cripple the relay, even at ambient temperatures from −85 to 250 F. Corrosive atmospheres, salt spray humidity, tumbling, fungus, and explosions can also be rendered harmless. But each increase in protection is a costly extra step in production. Is it necessary? And must the relay operate *during* or just *after* the adverse conditions?

Shock and vibration resistance are achieved in almost as many ways as there are relay manufacturers. In some new designs, permanent magnets hold the contacts closed under shock and vibration. Others have dynamically balanced armature and contact systems. Still others feature rigid, heavy movable members that will resist the forces trying to shift them.

Allowable increases in ambient temperature result from new insulating materials and techniques. Right now the major barrier to still higher ambient temperatures is the inherent increase in resistance with temperature of the copper used for magnet wire. At 500 F, the coil current (and therefore pull-in force) is less than half what it would be at 70 F for the same applied voltage.

REPRINT of this article can be obtained for your reference file by checking No. E50 on one of the Reader Service cards bound in this issue. For other reprints available see "Current Reprints" listing in this issue on page 115.

EDITOR'S NOTE: For other articles covering various phases of the broad subject of electromagnetic relays see articles listed below.

Telephone type relays (also useful for industrial controls): "Relays for Step-by-Step Circuits," Nov 11 '57, p 101—versatile stepping relay switches 100 circuits in sequence; the nonstepping telephone type was covered in a series—"Electrical and Mechanical Detail," Oct '50, p 130; "Coil Construction and Timing," Nov '50, p 141; "Arc Suppression and Contacts," Feb '51, p 136; and "Typical AC and DC Circuits," Mar '51, p 125.

For adverse atmospheres: "Encapsulated Relays," Mid-Oct '57, p I 2,—keeping contacts under glass in special atmospheres eliminates contact oxidation. (An external electromagnet operates the contacts).

Electronics plays a part in these electromagnetic relays: "Photoelectric Relays and Circuits," Mid-Oct '55, p I 29—photocells and selenium resistance-bridges trigger amplifiers to operate relays; "Switching—Transistor Versus Relays," Mid-Oct '57, p I 7—transistors are recommended for logic relay applications.

Time-delay relays are possible with air or liquid: "Pneumatic Time-delay Relays," Jan '56, p 174, gives theory and applications (with circuit diagrams) for air-bleed time-delay relays; "Mercury Plunger Relays," Mar '56, p I 82—immersed cylindrical shell displaces mercury upward to cover contacts and also permits time delay by trapping inert gas above mercury.

Circuit design using relays will be aided by: "Switching-logic Functions," Aug '57, p 196, defines AND, OR, NOT, and MEMORY notations; "Simplifying Relay Control Circuits," Nov '56, p. 162, switching-algebra method helps keep relay circuits to minimum.

Detailed announcements of other significant relays have been: "Snap-action Relay," Aug 11 '58, p 37, rolling spring operates instantly and holds contacts when triggered; "Magnetic-toggle Relay," Aug 11 '58, p 42, preferential magnetic path assures quick operation on brief signal pulse and holds in either direction; "Magnetic-ball Relays," Feb 24 '58, p 40, plated balls aligned in magnetic field increase life and reliability of relay by multiplying points of contact, simultaneously assuring random points of wearing and arcing.

the case for SWAGING

Recently introduced swaging machines have increased usefulness of this high-speed method for shaping metal. The author gives tips on choosing suitable materials, and specifying shapes and tolerances.

LLOYD A WHITING, *Chief Engineer*
Swaging Machine Div, The Torrington Company

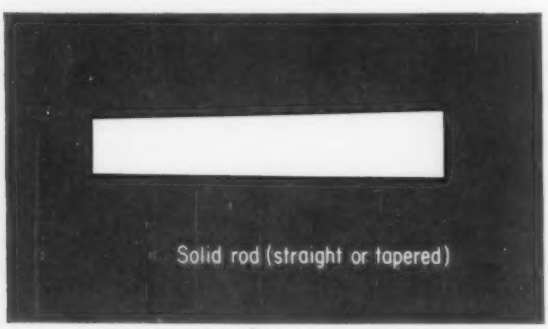
Even something as old-fashioned as swaging—which the village blacksmith practiced in a slow-motion manner—can go modern. Each pounding blow nowadays is more powerful and can be repeated at a rate as high as 4000 per minute. And new-type rotary swaging machines add advantages to what has become a high-speed method for shaping metal—to tolerances between those of good machining practice and precision grinding technique. Let us see what it is that today's swaging can do, which materials to choose, and when to specify the process.

The method works metal with formed dies that slide in and out radially while revolving within a cage of rollers. Centrifugal force opens the die halves—and the die backers, striking the rollers, force the dies inward at a fast-pounding rate. Blows per minute vary from 1800 in large machines to about 4000 in the smallest ones.

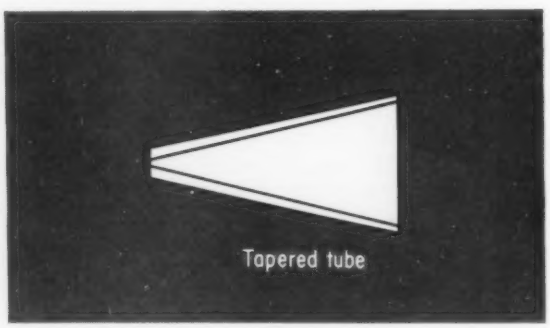
Reducing the outer diameter of solid bars is one of the simplest jobs that can be handled by this method. Oversized bars are hammered to accurate size and the excess material is squeezed out as additional length. No material is wasted. Hot-rolled steels can be swaged to within cold-rolled limits and also be given improved surface finish—for about $\frac{1}{10}$ the premium cost of cold-rolled. Swaging can also reduce bars with cross-sections other than round, although the final swaged area is always round. In addition, the newer die-closing machines permit necking in the center without working from either end.

Tapering hollow shapes gives venturi tubes, nozzles and other irregular structural shapes. Here, swaging-down the diameter crowds more material into the wall section. A common size for tapered tubing—widely used in furniture, for example—is 1 to 1¼ in. OD reduced to ⅝ in., with the tapered length running from 5 in. to 28 in. The longer lengths are usually swaged in more than one step. The limiting factor on maximum tubing diameter is wall thickness. A good maximum figure for thick-

DIMENSIONING AND TOLERANCES FOR SWAGED SHAPES



Size	*Tolerance*
¼ in.	±0.001
⅝ in.	±0.002
1 in.	±0.003
for each additional ½ in., add	±0.001



- Outer surface—same tolerances as for solid
- Inner surface cannot be controlled without mandrel
- With mandrel, min wall thickness is about 0.030 in.

ness is 1/40 of the OD, though this varies somewhat with material.

MATERIALS FOR SWAGING

Ideally, a material for swaging should allow elongation of at least 25% and a good spread between the yield and ultimate strengths. For ease of swaging, materials can be ranked in this order: phosphorized copper, copper, aluminum, brass, plain carbon steel, then stainless steel. The nickel-base alloys like monel and Inconel are generally difficult to swage, as are titanium, zirconium, uranium and rhenium. However, limiting the reduction in each pass and increasing the number of passes will often swage these materials. Or, the swaging action may be altered to give a squeezing rather than a hammering blow. In general, it is easier to shape the softer-annealed materials because they are more ductile. For example, copper tubing swages more accurately than stainless because of less springback.

Best stainless steels for swaging are these: 302, 304, 305, 321, 347, 403, 410, 430, 443 and 446. If stainless parts must be machined afterwards, the 400 series is preferred—these straight-chromium stainless steels do not work-harden as severely. Best types here are 403, 410, 430 and 443. Leaded materials, regardless of the base alloy, are poor in swaging because the lead initiates cracks.

Aluminum swages easily—except under high local pressures. These may weld the aluminum part to the dies, causing galling. Designs should therefore be limited to a 20°-included angle. Anything steeper is out of the question, whereas with other swaged materials, 20° can be exceeded sometimes. Aluminum alloys with copper additions are troublesome too—they age at room temperature and lose swaging qualities.

Preplated materials normally can be swaged and tapered without peeling the coating. Even chromium plating can be swaged, but it has a tendency to wear the dies more than other coatings do.

Ordinary welded tubing may have hard spots or surface discontinuities that cause excessive tool wear or buckling of the part during swaging. Swaging seamless tubing may seem an added expense, but will often lower rejects enough to make it pay.

Surface finish on OD of swaged parts is usually improved. On the ID of hollow shapes this picture is reversed . . . a slightly rougher surface results because the material, under compression, gathers locally. One solution, where this factor is important, is to swage against a mandrel—giving the inner surface the finish of the mandrel.

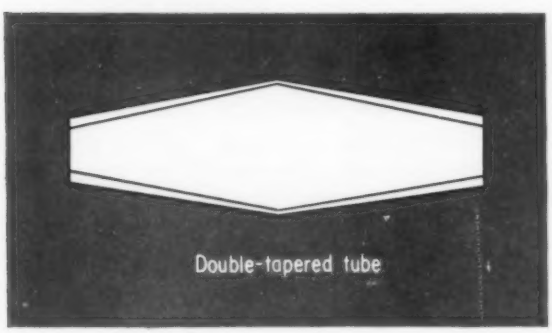
WHERE SWAGING STANDS OUT

High speed	**1 in./sec, average** **5 in./sec, for sizing**
Stronger parts	**Its cold-working strengthens materials** **Slender parts gain needed strength**
Good surface finish	**20 microin. is normal** **15 microin. in certain cases**
Straight parts	**Part worked uniformly around circumference**
Roundness and close tolerances	**Equivalent to cold-drawn shapes**

EDITOR'S NOTE: For comparison of swaging with other cold-forming processes that make similar parts, see:

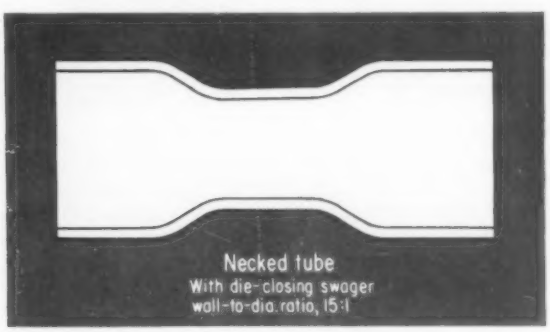
"Power-spinning Conical and Tubular Parts," Aug '56, p 135—compares spinning with other processes; gives effect on strength hardness and fatigue; explains how to specify tolerances and finishes.

"Pressing Can Make Complex Shapes," Jan 6 '58, p 62—tells how combining pressing operations can give complex one-piece designs.



Double-tapered tube

- Outer surface, same tolerances as for solid
- Inner surface cannot be controlled
- Small ID can be held to normal tolerances with straight mandrel



Necked tube
With die-closing swager
wall-to-dia. ratio, 15:1

- Outer surface—same tolerances as for solid
- Inner surfaces—small ID can be held with straight mandrel; inner taper cannot be controlled

Who's Minding The Store?

. . . in the magazine publishing business, it's

The Audit Bureau of Circulations (ABC) is a cooperative organization that sets standards of good business conduct for its publisher members. Once each year ABC auditors carefully scrutinize the entire circulation structure and operation of every member magazine. In a very real sense, therefore, they are "minding the store" — making sure that no false or misleading claims are made regarding the size or composition of a magazine's audience.

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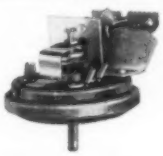

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- **Compact design**
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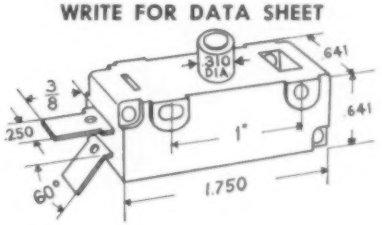
WRITE FOR DATA SHEET



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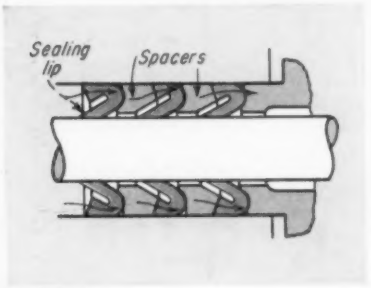
PACKED GLANDS for

These 11 design ideas cover spacers, leak-off points and radial sealing. Basic principles and types of packings were illustrated in the Nov 10 issue. Both articles give highlights from "Packed Glands for High Pressures: An Analysis of Fundamentals," by Professor J. L. Thomson, and published in England by the Institution of Mechanical Engineers, 1 Birdcage Walk, London SW1.

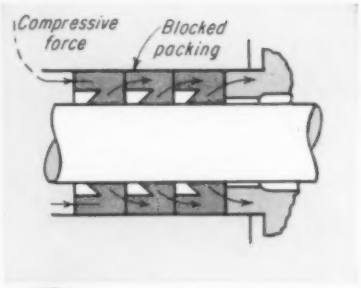
HOW TO BEEF UP SOFT PACKINGS

Spacers with soft packing are an alternative when hard packing is not practical for the gland.



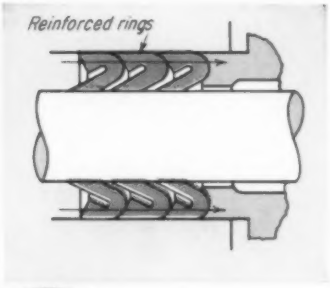
1

Formed spacers . . . transmit axial load caused by internal pressure. The load is transmitted from ring to ring; each sealing lip is left free to conform to the rod surface. This avoids excessive friction forces that occur with soft packings.



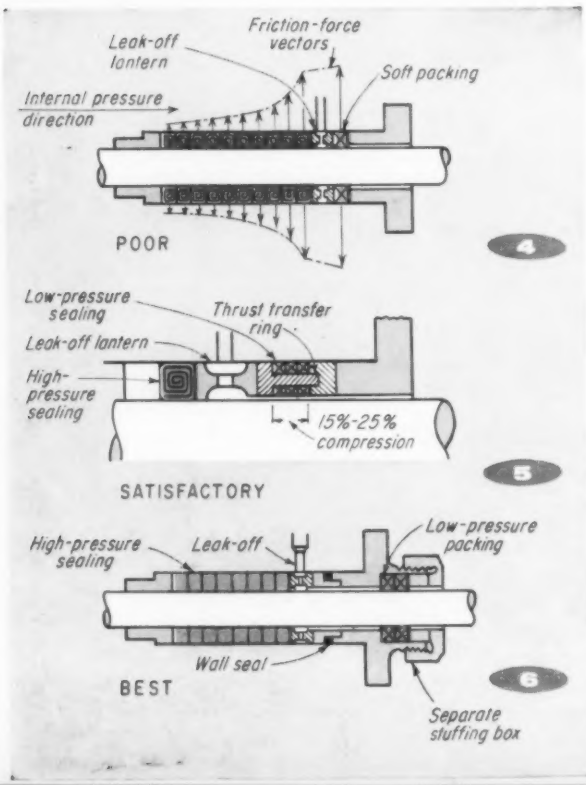
2

Blocked packing . . . is specially designed to carry axial load on the block portion, leaving the sealing portion flexible. Each sealing lip acts independently.



3

Lipped rings . . . perform same function as in (1) and (2), but wire mesh reinforces ring heel. Load-carrying heel is therefore stiff enough to prevent excessive ring-squeezing—avoiding high friction forces and the resulting rod wear. Designs (2) and (3) are less efficient than (1).



LEAK-OFF RINGS

Also called "lanterns," they are recommended for all high-pressure glands. They prevent wastage and mess by collecting leakage and conducting it back to the system. Seal leak-off lanterns with soft packing—but watch your design!

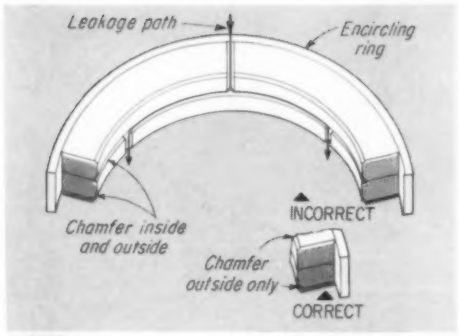
Poor design (4) . . . is completely at variance with the theoretical ideal because the full compressive load from internal pressure, squeezing the soft packing, gives excessive friction load on the rod. Much wear and overheating results.

Satisfactory design (5) . . . is simple way of overcoming the problem. Thrust-transfer ring limits the low-pressure packing to about 20% compression.

Best design (6) . . . has separate, low-pressure stuffing box. High-and low-pressure packing are separate, thereby increasing gland efficiency and improving maintenance.

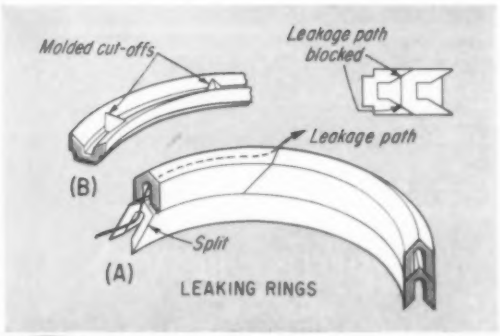
HIGH PRESSURE

RADIAL SEALING



7

Leakage paths . . .
in floating rings are avoided by chamfering the outer edges only. Such chamfer will prevent the rod from being scraped clean of lubricating oil. This is especially necessary for high-pressure gas seals.

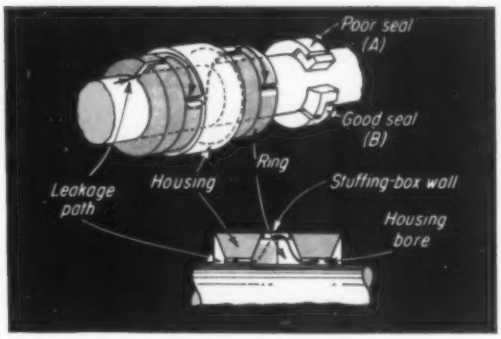


8

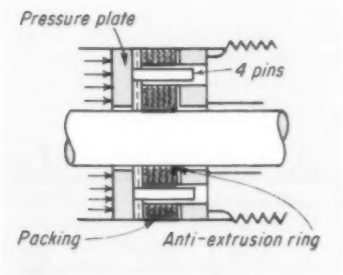
Split rings . . .
allow leakage (A) through internal channels even if the joints are staggered. Modified section (B) limits circumferential circulation to a relatively small arc.

9

Metallic packings . . .
with conical faces fitted to mating faces on the housing may leak by way of the stuffing-box wall and the housing bores. Half-lapped rings (A) do not seal leakage path but joint (B) is satisfactory.

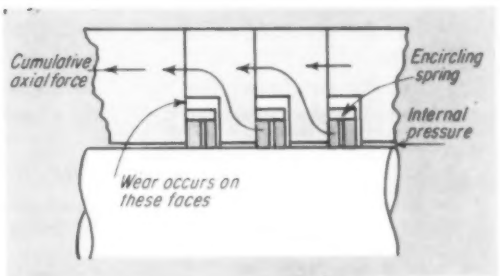


OTHER GLAND DESIGNS



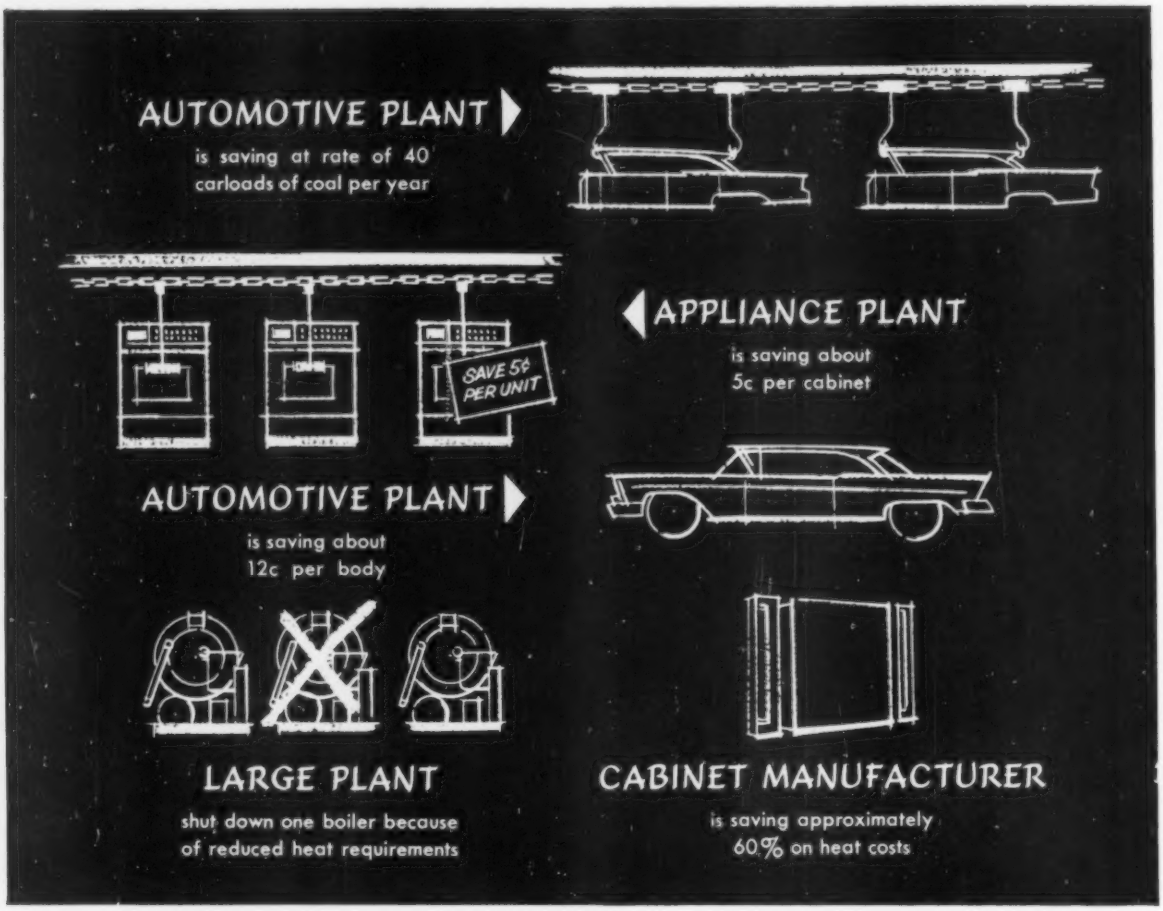
10

Single packing ring . . .
for liquid spring has no initial compression yet seals exactly the same way as a stuffing box. Sealing force results from internal axial pressure squeezing the pressure plate against the packing. When only one ring causes the entire pressure drop, an anti-extrusion ring must be fitted. Such seals require a rubberized-fabric packing ring and a hard-chromium-plated rod.



11

Multi-compartment gland . . .
avoids buildup of axial force because individual spaces isolate packing elements—force is taken by compartment walls. Each element is subjected merely to an axial force caused by the pressure drop across itself. When this is not excessive, the element is free to float with the rod—alignment changes are thus tolerated.


AUTOMOTIVE PLANT
is saving at rate of 40 carloads of coal per year
SAVE 5¢ PER UNIT
APPLIANCE PLANT
is saving about 5c per cabinet
AUTOMOTIVE PLANT
is saving about 12c per body
LARGE PLANT
shut down one boiler because of reduced heat requirements
CABINET MANUFACTURER
is saving approximately 60% on heat costs

high quality coatings... spectacular savings, too! New COLD BONDERITE SYSTEM

These are not isolated cases. Everyone saves when they change from conventional hot phosphating to the new Cold Bonderite System!

The difference is in heat required. Cleaner, rinse and Bonderite operate 40° to 75° cooler than in conventional installations.

Results produced by the Cold Bonderite System equal the highest Bonderite quality standards. Chemical costs are comparable to hot systems.

Many plants, from the largest on down, have changed to the Cold Bonderite System in their finishing lines. They've cut costs drastically. You can, too. Write or call today!

PARKER RUST PROOF COMPANY
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BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

Since 1914— leader in the field

*Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

for faster computation . . .

CHART ANALYZES SINUSOIDAL MOTION

Quick method finds speed, acceleration, force and other values for spring-supported masses.

Dr K W MAIER,

Manager, Advanced Research & Development
Olin Mathieson Chemical Corp, New Haven, Conn.

Many design problems center on motion equations for spring-supported masses. Other, similar reciprocating motions, although not spring-powered, can also be solved by these equations. Examples of both cases are: a cantilever with a heavy mass attached to the beam end; a coil spring mounted with a vibrating component, and a crank drive with a long connecting rod and heavy flywheel.

The chart on the continuing page allows such factors as time, displacement, velocity and acceleration to be found with a shorter computation method than when standard motion-equations are used.

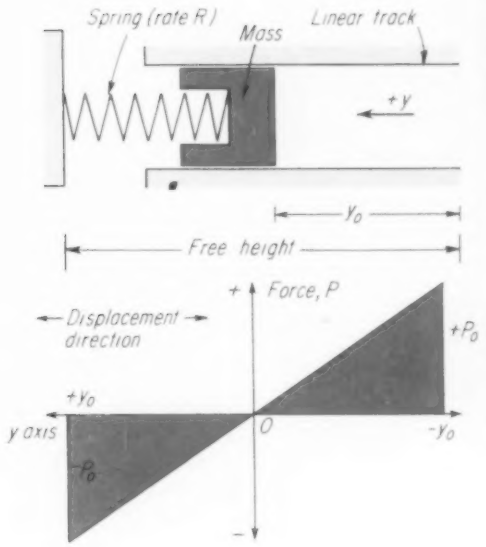
HOW THE CHART WORKS

The cyclic motion of the mass is represented by a point on the specific-time circle. Project the point to the horizontal scale for specific displacement, specific acceleration and specific force. (The last two values have to be read with opposite sign.) Project the point to the vertical scale for specific velocity. Any one of the horizontal, vertical and circular coordinates will determine the fixed point on the circle. The other two specific coordinates may then be found.

An entire motion phase is represented by an arc extending from a point of initial condition to a point of final condition. Example: The extension of a spring from a certain initial deflection y_o to a final deflection, $y_o/2$ (for $y/y_o=0.5$) is described by a 60° arc extending from zero to 0.167—one-sixth of the period. On the other hand, the total contact phase of a moving mass striking a free spring covers a semicircle: first, the compression stroke extending from $t/T = 0.75$ to $t/T = 1$; then the extension stroke to $t/T = 0.25$ (i.e. $t/T = 1.25$).

The radius vector itself has a definite physical meaning also. It can be considered as representing the total energy of the mass-spring system. The horizontal and vertical components of the radius vector therefore indicate the instantaneous amounts of potential energy of the spring and kinetic energy of the mass, respectively.

(Continued on page 79)



SYMBOLS

Time

- t = time coordinate, sec
- T = total time of one complete oscillation o period, sec
- t/T = specific time, dimensionless

Distance

- y = linear deflection of spring (also mass displacement) from free height, in. (positive in compression)
- y_o = initial (max) deflection of spring in compression, in.
- y/y_o = specific displacement, dimensionless

Velocity

- v = final velocity of mass or spring end, in./sec
- v_N = velocity when passing neutral position ($y = 0$) in the direction of compression, in./sec
- v/v_N = specific velocity, dimensionless

Acceleration

- a = acceleration of mass, in./sec² (+ in direction of spring compression)
- a_o = acceleration at max extension ($-y_o$), in./sec²
- a/a_o = specific acceleration, dimensionless
- g = gravity = 386.4 in./sec²

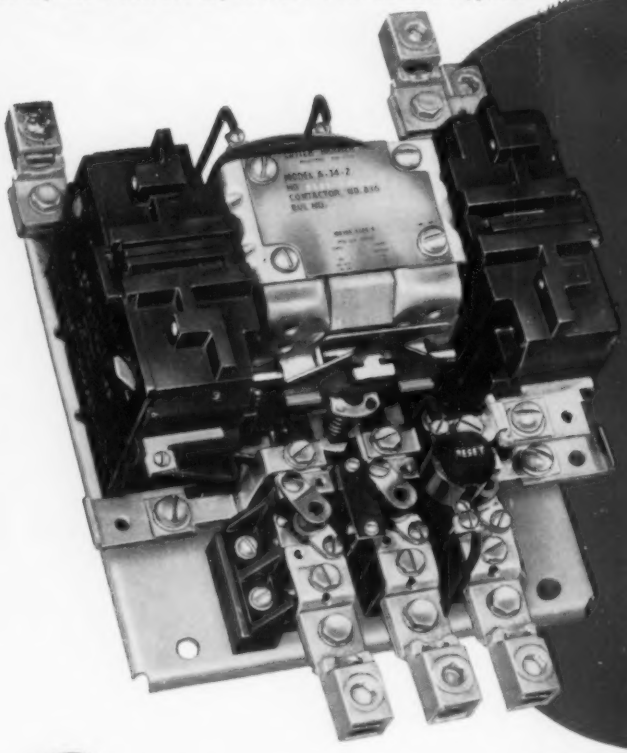
Force

- $P = Ma$ = spring force acting on mass, lb
- P_o = spring force acting on mass at max extension ($-y_o$), lb
- R = load/deflection = spring rate, lb/in.
- P/P_o = specific spring force, dimensionless

Weights and masses

- W = weight of moving part, lb
- $M = W/g = W/386.4$ = mass of moving part, sec² lb/in.
- m_S = spring mass, sec² lb/in.

50 Hp 220 Volts, 100 Hp 440/550 Volts Max. Polyphase



New SIZE 4 STARTER

. . . another Cutler-Hammer Three-Star achievement

New — *compact design saves valuable panel area*

New — *parallel contact design provides increased electrical life at full capacity*

New — *low mass movable members insure superior mechanical life*

This is the new Cutler-Hammer NEMA Size 4 Starter . . . industry's first large horsepower starter offering all the desired features of the famous Cutler-Hammer Three-Star Motor Control line. Smaller, more compact, this new starter simplifies control panel design and saves valuable panel area. Tests of the new parallel contact structure show vastly improved electrical life even when operated at full capacity. Further, this new design reduces the size and weight of the movable members resulting in less impact wear and unsurpassed mechanical life. We've tested it against all others, why don't you? The new Cutler-Hammer Size 4 Starter ☆ installs easier, ☆ works better, ☆ and lasts far longer. Get all the facts today. Write for the new descriptive bulletin EN125-W249, Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

Look for these outstanding features . . . you'll find them only in Cutler-Hammer Three-Star Motor Control

- U-shaped cover easily removable for unobstructed inspection and accessibility
- Straight through wiring . . . line terminals at the top, load terminals at the bottom
- New pressure type terminals cut wiring time and effort
- Adjustable overload relays can be set to trip within 3% of full load motor current
- Precision cast overload sensing coils can't lose their accuracy
- Widely desired three-phase, three-coil overload protection is a standard optional feature . . . no special attachments or enclosures
- Indestructible molded magnet coil . . . color coded for positive voltage and frequency identification
- Easily installed convertible electrical interlocks require no special adapters . . . provide up to four extra control circuits
- Available as non-reversing, reversing, and multi-speed contactors and starters in the open type, NEMA 1, and all special purpose enclosures.

CUTLER-HAMMER CONTROL C-H

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wis. *Division:* **Airborne Instruments Laboratory.** *Foreign:* **Cutler-Hammer International, C. A.**

Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation, Inc.

SINUSOIDAL MOTION (cont.)

Working Example

For a linear mass-spring system:

Mass weight = 10 lb, spring rate = 25 lb/in., initial deflection = 4 in., final deflection at end of stroke = 2 in. Since $y = 2$ and $y_o = 4$, $y/y_o = 0.5$. An ordinate from this value cuts the circle at $t/T = 0.167$ and $\frac{v}{v_N} = 0.866$

From the formula table at right, unit values are

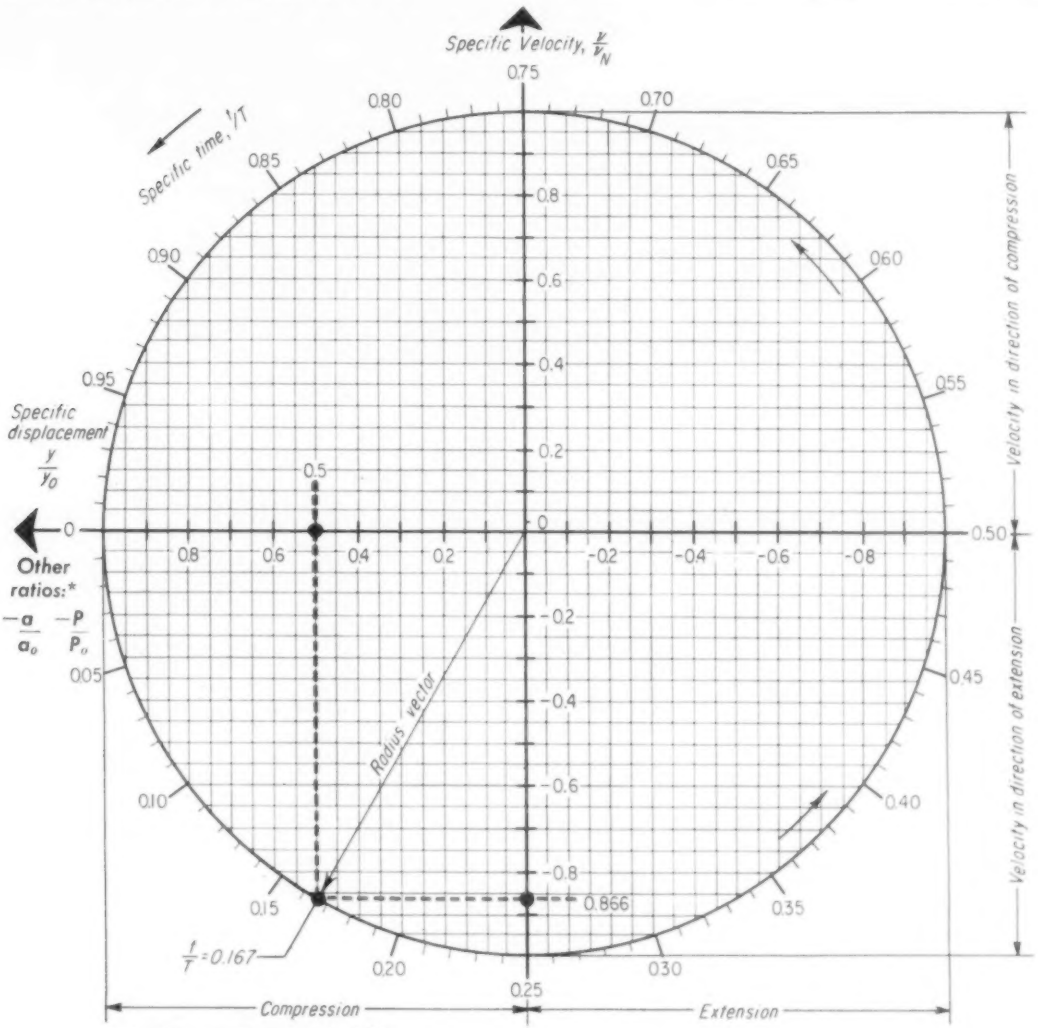
$T = 2\pi\sqrt{10/25g} = 0.202$ sec
$v_N = 2\pi(4/0.202) = 124$ in./sec
$P_o = (25)(4) = 100$ lb
$a_o = 100g/10 = 3864$ in./sec$^2 = 10g$

Absolute values describing the final status of the mass are found by multiplying the specific values by corresponding variable units.

$t = (0.167)(0.202) = 33.7$ millisecs
$v = (-0.866)(124) = 107$ in./sec
$P = (0.5)(100) = 50$ lb
$a = (-0.5)(3864) = -1932$ in./sec$^2 = -5g$

FORMULAS FOR VARIABLES

Variable Units	Formula	Description
Time	$T = 2\pi\sqrt{W/Rg}$	Period of oscillation
Displacement	y_o	Max deflection in compression
Velocity	$v_N = 2\pi\, y_o/T$	Max velocity in compression
Acceleration	$a_o = 39.5\, y_o T^2 = P_o g/W$	Max acceleration in extension
Spring Force	$P_o = Ry_o = Wa_o/g$	Max spring force in extension



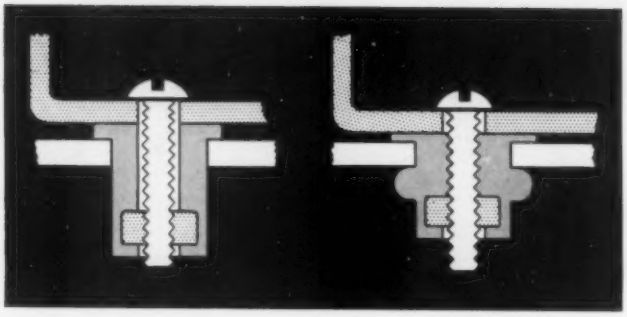
* Specific acceleration is $\left(\frac{a}{a_o}\right)$
Specific spring force is $\left(\frac{P}{P_o}\right)$

There is no substitute for stainless steel in automobiles

No other material is as bright, strong and resistant to rust and wear as Stainless Steel. It gives every car the clean, exciting beauty that sells in the showroom and re-sells on the used car lot. Look for *Stainless Steel* on your new automobile.

Specify McLouth high quality sheet and strip Stainless Steel. McLouth Steel Corporation, Detroit 17, Michigan.

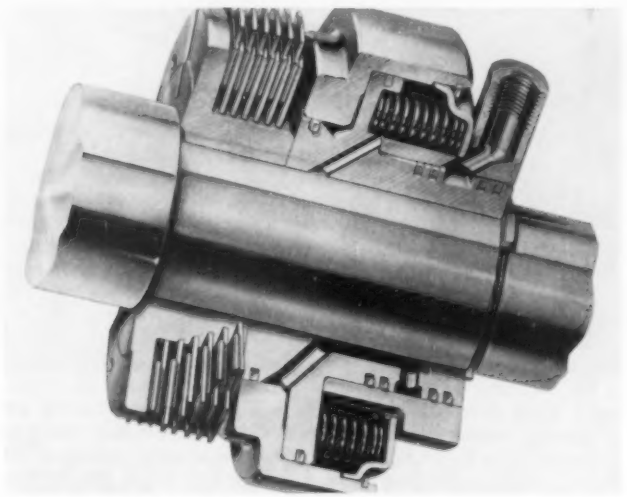
McLOUTH STAINLESS STEEL



Vibration-resistant fastener . . .

is a neoprene bushing of special composition with threaded brass hex nut bonded in one end. Installs with screwdriver. Brass nut draws neoprene against back of material, providing a firm hold. Offered in three new sizes with flanges of 0.750, 0.562 and 0.750 in. dia and flange thicknesses of 0.187, 0.125 and 0.187 in. Threads in brass hex are 10-32, 10-24 and ¼-20, respectively. Applicable as a blind fastener, as a vibration isolator, as an airtight, oil-resistant, watertight seal, where panels are too thin to take self-tapping or set screws, and over a wide thermal range. Fasteners are 2 to 8¢ each, depending upon size and quantity. From stock. **Rockwell Products Corp, 146 Central Ave, Newark 3, NJ.**

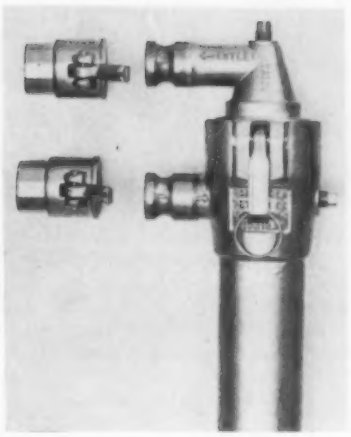
Circle 1, Reader Service Card



Multiple-plate clutches . . .

for machine tools, transmissions and similar applications run in oil and are actuated by oil pressures of 100 to 300 psi, depending on applications. Line includes clutch with integral stationary oil collector, to which ¼-in. NPTF line is connected, and shorter clutch that is identical except for omission of around-the-shaft collector. End shaft-seal can be used on this model by drilling shaft accordingly. Both are available in sizes from 3 to 7 in. dia, transmitting up to 137 hp and up to 690 lb-ft of torque. With hydraulic balance, speeds to 5000 rpm max for smallest sizes and to 3250 rpm max for largest are allowable. Forced cooling, by pumping oil through plate stack, permits transmitting 30 to 40% more hp. Prices range from $64 to $235 list. Delivery, 30 to 90 days. **Twin Disc Clutch Co, Racine, Wis.**

Circle 2, Reader Service Card



Quick-coupling fine filters . . .

have flanged monel 316 stainless steel screens. Inlet, outlet and body are equipped with quick-couplers to simplify cleaning filter element and reusing it. Filters are non-short circuiting and are made 20 to 700 mesh for pressures to 300 psi and temperatures to 450 F. Bronze, steel or 316 stainless steel units are available. Filters are suitable for critical filtering applications. Elements withstand 150-psi differential pressures without collapse. Priced from $52 for single filter. Multiple automatic unit to $7000. Small units from stock; large units, 6 to 8 wk. **Ronningen-Petter Co, 330 S 27th St, Vicksburg, Mich.**

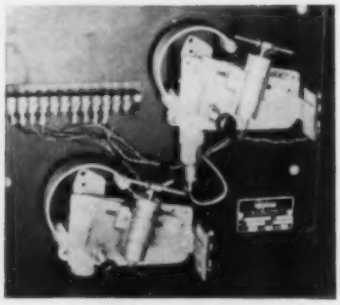
Circle 3, Reader Service Card

Clear anodize for magnesium . . .

alloys can be applied in less than 1 min. to sheet, extrusions, diecastings, sand castings and forgings. Used under a lacquer or varnish for max corrosion protection and to achieve metallic look. Lacquer or varnish tinted with commercial dyestuffs can be applied over clear anodizing to obtain transparent effect in wide variety of colors, which are said to have good permanence and are not washed out by detergents. Clear anodizing uses a 40-v current compared with 70 to 90 v for standard anodic treatment, of which it is a modification. Anodizing baths are identical. In 20% salt-spray tests, magnesium finished with clear anodizing plus lacquer or varnish is said to have withstood 500 hr without noticeable change. Available from Dow 17 processors. **Dow Chemical Co, Midland, Mich.**

Circle 4, Reader Service Card

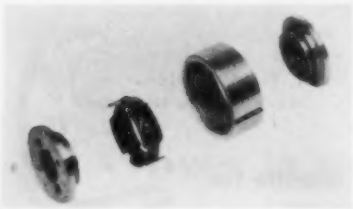
. . . CONTINUED ON PAGE 82



Psia transmitter . . .

measures liquid or gas pressures from 0 to 10,000 psia. Standard unit consists of two bourdon tubes mounted in semi-dusttight case, one tube evacuated and sealed to an absolute reference pressure and the other opening to line pressure. Differential transformers are mounted to send out electrical signals proportional to pressure applied to tubes. Transformers are wired together in electrical system with outputs bucking each other so that a differential signal is transmitted for accurate indication, recording control of absolute pressures. Temperature compensation is provided by thermistors mounted with each tube assembly. Standard tubes are made of K-monel. **Automatic Timing & Controls Inc, Dept 206, King of Prussia, Penna.**

Circle 5, Reader Service Card



Overrunning clutch . . .

has outer race that is loaded tangentially and is not subjected to high expansion loads, permitting it to be incorporated in a gear cluster, pulley or other assembly. Series of spiral-wound flat springs snub or lock. Bands or springs ride in a V-grooved inner race and tighten during rotation of either race to transmit torques. Reversal of direction backs off bands and permits free rotation. Engagement is said to be instantaneous and positive. **J-H Clutch Co, 16580 Northville Rd, Northville, Mich.**

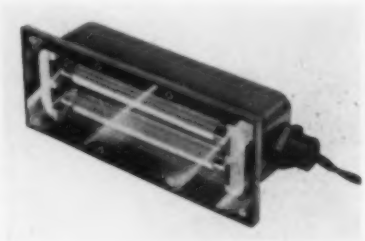
Circle 6, Reader Service Card

Teflon ribbon cable . . .

in widths of ¼ to 3 in. is woven of parallel Teflon lead wires with Teflon and other yarns. Slitting the ribbon is feasible for

construction of small, inexpensive harnesses. Increased numbers of conductors can be placed in square or rectangular channels, resulting from space-saving factor of square and rectangular harness constructions. Flexible ribbon cable can be applied in applications where motion is involved, such as being pulled over rollers, coiled on drums—and as connections between chassis and panel doors. **Hitemp Wires Inc, Engineering Dept, 1200 Shames Dr, Westbury, NY.**

Circle 7, Reader Service Card



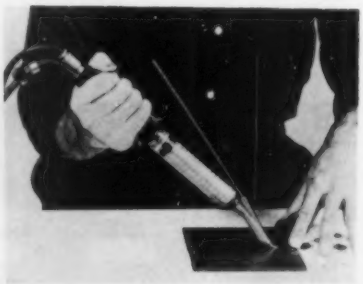
Miniature fluorescent lights . . .

for applications where moisture, coolants, dirt and chips render ordinary lights inadequate. Utilizes two 4-w fluorescent lamps and ballast in a sealed reflector. Provides up to 500 ft-candles at 3 in. Built-in clear plastic shield protects unit. Fixture contains auto-start ballast and is fitted with ½-in. straight pipe thread for permanent mounting. On-off switch for remote control eliminates need for starters. Lamp life is about 3 yr on 8-hr burning cycles. **Stocker & Yale Inc, Marblehead, Mass.**

Circle 8, Reader Service Card

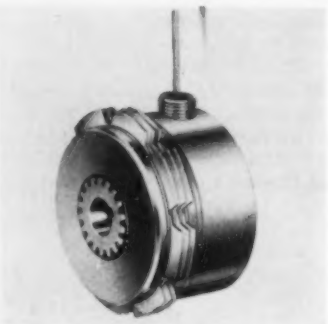
Welder for thermoplastics . . .

operates on 110 v ac, without voltage regulation, and compressed air or nitrogen. Users are said to report average speeds of 48 in. per min. on simple flat or curved surfaces. A wide choice of temperatures is offered by selecting proper heating element and adjusting air-flow rate for



particular thermoplastic being welded. Auto-feed tip leaves one hand free to steady or turn work and to insert new rods. **Seelye Craftsmen, 984 Central Ave., Minneapolis 13.**

Circle 9, Reader Service Card



Disk-type electric clutches . . .

with stationary magnetic coil are available in sizes from ¾ to 3½-in. bore and up to 2400 lb-ft of static torque. Clutches and brakes combine disk assembly design with new electromagnetic mechanism, which holds clutch or brake in engaged position by action of magnetic flux passing through buttress plate, disk assembly and end plate. Upon release, separators not only separate disks, but break up residual magnetism. In case of current failure or safety device cutout, clutch disengages. Clutch or brake units and controls are furnished with 40-in. coil leads, ready to install. Standard operating voltage is 90 v dc at low wattage. **Carlyle Johnson Machine Co, Manchester, Conn.**

Circle 10, Reader Service Card

Fhp control motor . . .

is said to withstand adverse environmental conditions and abuse encountered in processing and chemical industries and industrial automation applications. Dc motor, rated ⅛ hp at 4000 rpm, can be incorporated in control equipment. Available with integral tachometer-generator giving 0 to 5-milliamp output signal line-

. . . CONTINUED ON PAGE 84

EXTRAORDINARY BEARING PROBLEMS?

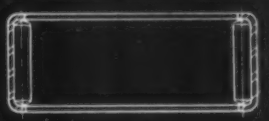
"REALI-SLIM" BALL BEARINGS

Ball radial | Angular contact | 4-pt. contact

Cross sections from ¼" to 1" and 4 to 40" bore diameters. Some sizes available from stock.

THIN SHELL NEEDLE BEARINGS

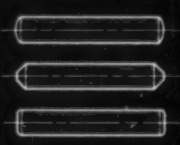
NEW!



Type KN

Standard sizes — in stock

NEEDLE ROLLERS

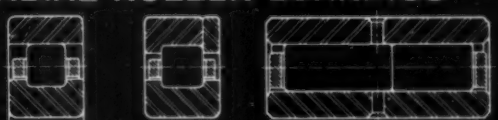


Spherical, conical or flat-end types

RADIAL BALL BEARINGS

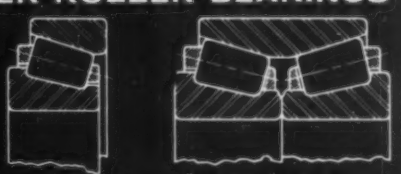
Conrad design, types LC, HC and BLC | Maximum capacity design, types HM, BLM | Angular contact design, types HA, BLA

RADIAL ROLLER BEARINGS



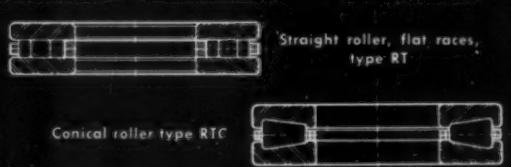
Lipped inner, straight outer race types RN, RX and RNW | Lipped inner, one lip outer, side ring type RP | Straight inner, straight outer, mill type RM

TAPER ROLLER BEARINGS



Single row type TS | Two row, non-adjustable type TNA

THRUST ROLLER BEARINGS



Straight roller, flat races, type RT

Conical roller type RTC

THRUST BALL BEARINGS

Grooved race type BT | Angular contact type BTA

Flat race type BTE

ECONOMICALLY SOLVED AT KAYDON

When bearing problems seem next to impossible — when design considerations appear insurmountable — it's time to call KAYDON.

You'll find KAYDON'S full-time, experienced bearing-design engineers can take your problem in hand — and take worries off your mind. Their record is one of remarkable success — designing and producing bearings others said "couldn't be made."

Extraordinary bearing problems are KAYDON'S daily assignment. The tougher the better! If your designs require bearings of exceptional thrust or radial capacity, close-tolerance precision and/or *"Reali-Slim"* section, or extra-large diameter bearings up to 130" O. D., call or write KAYDON for specific recommendations, economical solutions. You'll be glad you did.

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

K-572

All types of ball and roller bearings — 4" bore to 178" outside diameter . . .

Taper Roller • Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust Bearings

arly proportional to speed. Continuous-duty peramanent magnet motor is totally enclosed and has torque output of 40 oz-in. Speed range is 0 to 4000 rpm. **Rotron Controls Corp, Woodstock, NY.**

Circle 11, Reader Service Card

Polyethylene wire-ties . . .

grip and disengage quickly for repairs or adding new wires. Tie may be reused without affecting operation and detached without danger of cutting wires. Said to have high dielectric properties and a 45-lb breaking point. Ties are chemically inert and heat-resistant. **Richco Plastic Co, 4445 W Fullerton Ave, Chicago.**

Circle 12, Reader Service Card

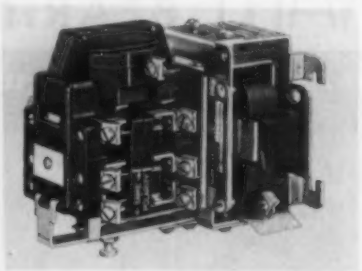
Contour cushion seat . . .

for heavy-duty mobile equipment is padded with 4 in. of foam rubber in seat and 2 in. at back. On steel base. Covering materials, in various colors and types, include flexible cowhide, elastic Naugahyde and silver Koroseal. Air holes at back of unit provides ventilation. Available with various suspensions. **Milsco Mfg Co, 2758 N 33rd St, Milwaukee.**

Circle 13, Reader Service Card

Mechanically held relays . . .

for control panels mount in same panel space as standard electrically held relays. Relays can now be mounted on control panel in same sequence as they appear on elementary diagram. Offered as factory-assembled units or as electrically held relays and mechanically held attachments for customer assembly. Rated 10 amp, 6



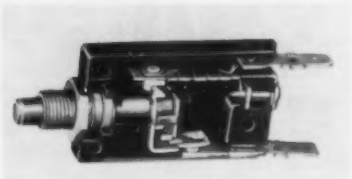
to 600 v ac, 50 to 60 cps. Offered in units with 2 to 10 contacts. Relays are priced at $30 to $58 each, depending on model. Attachment is $14. **Square D Co, 4041 N Michigan Ave, Chicago 11.**

Circle 14, Reader Service Card

High-speed solenoid . . .

designed to operate with a 24-lb load, completes its stroke travel in less than 20 millisec from circuit closing. Unit is for operation in ambient temperatures of −65 to 160 F. Voltage rating is 24 v dc and coil resistance is 19.2 ohm at 78 F. Solenoid is built in air-conditioned, dust-free atmosphere to meet government specs for aircraft, missile or ground-support applications. Over-all size is 1.65 x 2-in.-dia case. Square mounting flange with four holes is integral part of case. **Telco Sales Div, Telecomputing Corp, 915 N Citrus Ave, Los Angeles 38.**

Circle 15, Reader Service Card



Miniature circuit breaker . . .

avoids accidental circuit interruption. Trip-free mechanism prevents breaker reset while overload conditions prevail. Depression of reset button will not interrupt circuit once breaker is closed. Can be installed singly or in banks. Copes with surge currents up to five times rated current. Carries continuous current at ambient temperatures of 86 to 68 F. Models are available with ratings of 0.05 to 25 amp. **E-T-A Products Co of America, 6284 N Cicero Ave, Chicago 46.**

Circle 16, Reader Service Card

Hydraulic check valves . . .

for systems to 5000 psi are available in subplate-mounted and sandwich types. Blocks oil flow in one direction, allows

free oil flow in reverse direction. Offered in ¾ or 1¼-in. sizes. Subplate valves meet JIC standards and are available with or without matching subplate. Fits between subplate-mounted sequence valve and subplate itself. The ¾-in. valves allow volume of 20 gpm; 1¼-in. valves have flow of 65 gpm. Operation is based on spring-loaded poppet held on a seat. Flow occurs through valve at cracking pressure of 10 psi. May be mounted in any position. **Denison Engineering Div, American Brake Shoe Co, 1160 Dublin Rd, Columbus, Ohio.**

Circle 17, Reader Service Card

Nonlubricated coupling . . .

has one-piece nylon sleeve. Absorbs approximately 5° angular and parallel misalignment and end-float with min backlash, and is said to have run more than 800 hr at total misalignment with no signs of wear. Capable of operating over a wide temperature range at speeds to 5000 rpm. Available in 10 bore sizes from 7/16 to 1 5/8 in. Weighs 3½ lb. Prices are reported to be as low as one-half those of comparable steel couplings. **Sier-Bath Gear & Pump Co, 9249 Hudson Blvd, North Bergen, NJ.**

Circle 18, Reader Service Card

Noble metal contacts . . .

on poles permit grouping of electronic and standard control circuits for actuation by same magnet. Standard 10-amp industrial control circuits and electronic and instrumentation circuits may be switched with same relays. Available normally open or normally closed. Poles have contact tips of palladium-ruthenium alloy, a hard material with a high melting point and highly resistant to corrosion and tarnish. These

. . . CONTINUED ON PAGE 86

Hoover pillow blocks with ductile cast housings

Hoover introduces a new, economical pillow block ball bearing unit with cast housing of ductile material that absorbs shock and vibration, assuring long bearing life. It is designed to carry light loads at normal speeds.

The unit contains a pre-lubricated bearing featuring ultra-smooth *Hoover Honed* raceways and a perfectly matched set of *Micro-Velvet* balls, a guarantee of unexcelled quality. Known as the E D series, these new pillow block bearings are available in shaft sizes from ½″ to 1 3/16″.

Hoover also offers a cast iron pillow block bearing for light to medium load conditions, plus a wide range of flange and machine units.

WATCH QQ HOOVER!

hoover

BALL AND BEARING COMPANY

5400 South State Road, Ann Arbor, Michigan

Los Angeles Sales Office and Warehouse: 2020 South Figueroa, Los Angeles 7, California

Hoover Honed and *Micro-Velvet* are Hoover trademarks.

NEW BULLETIN 106 DESCRIBES COMPLETE LINE OF NEW HOOVER PILLOW BLOCK BALL BEARINGS!

Please return coupon for your copy

Hoover Ball and Bearing Company PE-11
5400 South State Road, Ann Arbor, Michigan

Please send new Bulletin 106, which describes Hoover pillow block ball bearings.

Name_____

Title_____

Company_____

Address_____

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for

UP OR DOWN

OR ROTARY POSITIONING

LimiTorque actuators are efficient, sensitive, automatic heavy duty power-operated units for *positioning machine parts or other assemblies requiring Linear or Rotary Motion.*

LimiTorque is an electro-mechanical mechanism, using motor power through highly efficient and precision gearing, to impart Linear or Rotary motion . . . Limit switches are available to limit the travel in either direction—Thrust and Torque responsive switches control thrust or provide emergency shut-off. With LimiTorque it is possible to control full travel accuracy to within .2%—LimiTorque is easily and accurately controlled by the mere "push of a button".

LIMITORQUE IS BACKED BY 30 YEARS' EXPERIENCE IN MOTORIZING ALL TYPES OF VALVES—WHY NOT CONSULT US REGARDING ANY PROBLEM YOU MAY HAVE INVOLVING LINEAR ACTUATION; OUR ENGINEERS CAN NO DOUBT HELP YOU SOLVE THAT PROBLEM.

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INDUSTRIAL GEARS & SPEED REDUCERS
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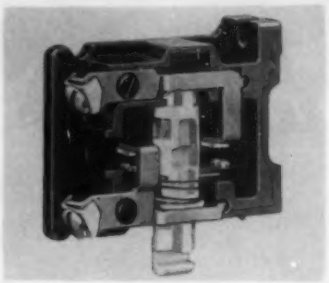
FLUID MIXERS • FLEXIBLE COUPLINGS
Limitorque Corporation • Philadelphia

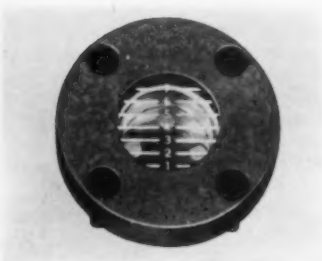


properties and a wiping action designed into the contact motion eliminate need to depend on arcing to break down contact surface resistance. Recommended for use in circuits of up to 600 v, drawing 0.5 v-amp or less. **Clark Controller Co, 1146 E 152nd St, Cleveland 10.**

Circle 19, Reader Service Card

Pilot-operated relief valve . . . has manually operated knob for instant changes in pressure settings. Offered with 0 to 20-gpm or 0 to 60-gpm capacity. Knob can change settings from 500 to 2000 psi, without tools. Especially suitable for machine tool application where different pressure settings are required frequently. **Webster Electric Co, Racine, Wis.**

Circle 20, Reader Service Card



Gearcase oil gages . . . permit instant check of oil level within transmissions or gearcases. Standard line, designed for aircraft applications, is offered

(Continued on page 91)

- Small size
- Reduced cost
- Long life
- Friction reduction
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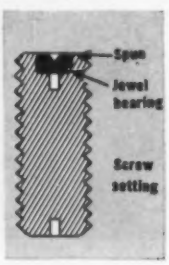
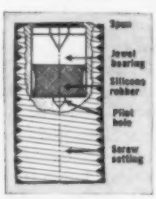


Bird Cushion Jewel Assemblies



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A new dimension in flexibility!

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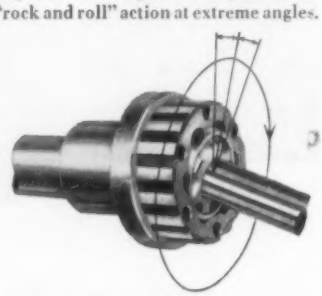
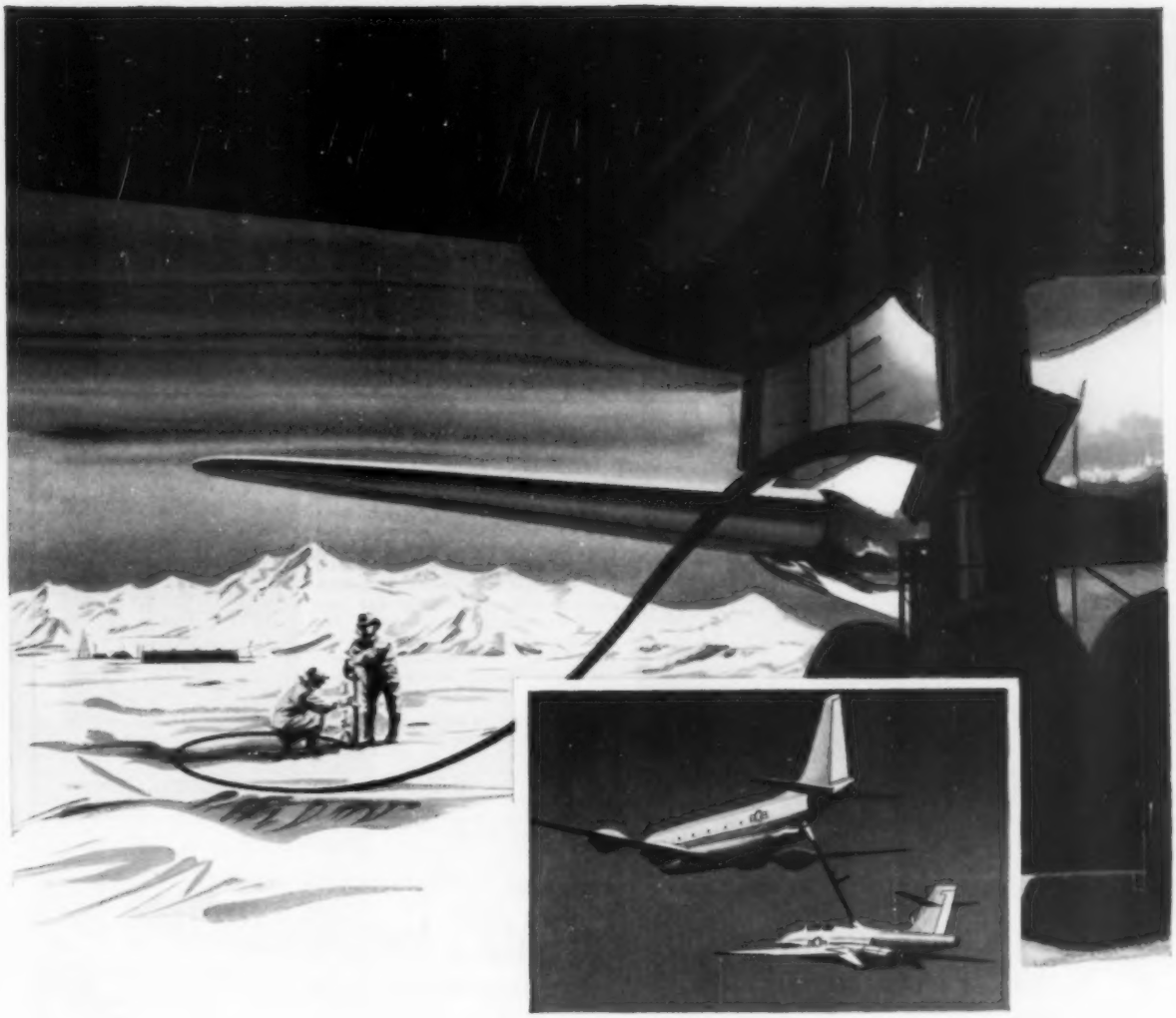
Plus RZEPPA'S smooth money-saving action

Old-fashioned pin or slipper-type joints speed up and slow down twice during one revolution, must use precision alignment techniques to compensate for "rock and roll" action at extreme angles.



Rzeppa Joints operate without chatter or bounce. Ball bearings deliver smooth rotation, reduce friction for longer joint and shaft life.



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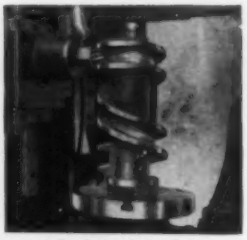

2-Revolution Index Cam

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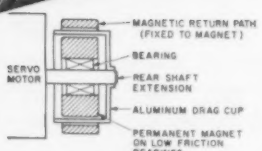
There's a lead-lag network in this SIZE 11 Frame!

EAD's Inertially Damped Servo Motors



One compact unit—EAD's high performance servomotor and an inertial damper. Electrically equivalent to a lead-lag network. This damper means: maximum velocity constants; excellent damping; line frequency insensitivity; no wiring or pick-up problems; suppression of residual noise; non-critical adjustments and no loss in shaft output. Meets significant military specs. Operates to 150° C. Supplied in sizes 10 and 15 as well.

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CIRCLE 143 READER SERVICE CARD

in five sizes, with sight diameters from ¾ to 2 in. Specially compounded plastic sight is available with permanent graduations. Sight is backed with cadmium-plated reflector that reflects oil level, even in dim light. Mounting flange is fitted with oil-tight gasket. **Gits Bros Mfg Co, 1866 S Kilbourn Ave, Chicago 23.**

Circle 21, Reader Service Card

Nylon-body solenoid valve . . .

is said to outlast and outperform steel. Dry seal threads require no compound; will not loosen under severe vibration. Hard-chrome-plated plunger is good for millions of operating cycles. With bubble-tight sealing, valve is offered in normally open, normally closed and directional control configurations, in all normal ac and dc voltages. Valve is said to be shock-resistant and pressure-proof. Prices start at $10.75. **Valcor Engineering Corp, 365 Carnegie Ave, Kenilworth, NJ.**

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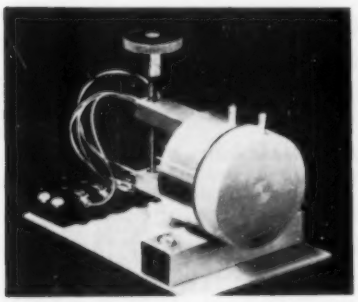

Pressure transducer . . .

measures small pressure differentials of 0 to 10 cm of water. Pressure drop is applied across thin metal diaphragm to which is fastened the core of a differential transformer. Zeroing screw positions core. Ac output has amplitude proportional to pressure differential across metal diaphragm. Sinusoidal voltage with 3 to 5-v amplitude and 400 to 20,000-cps frequency excites transformer primary. Dimensions are 2 in. dia x 3 in. **Custom Engineering & Development Co, 1429 S Ewing, St Louis 4.**

Circle 23, Reader Service Card

Hollow-shaft differentials . . .

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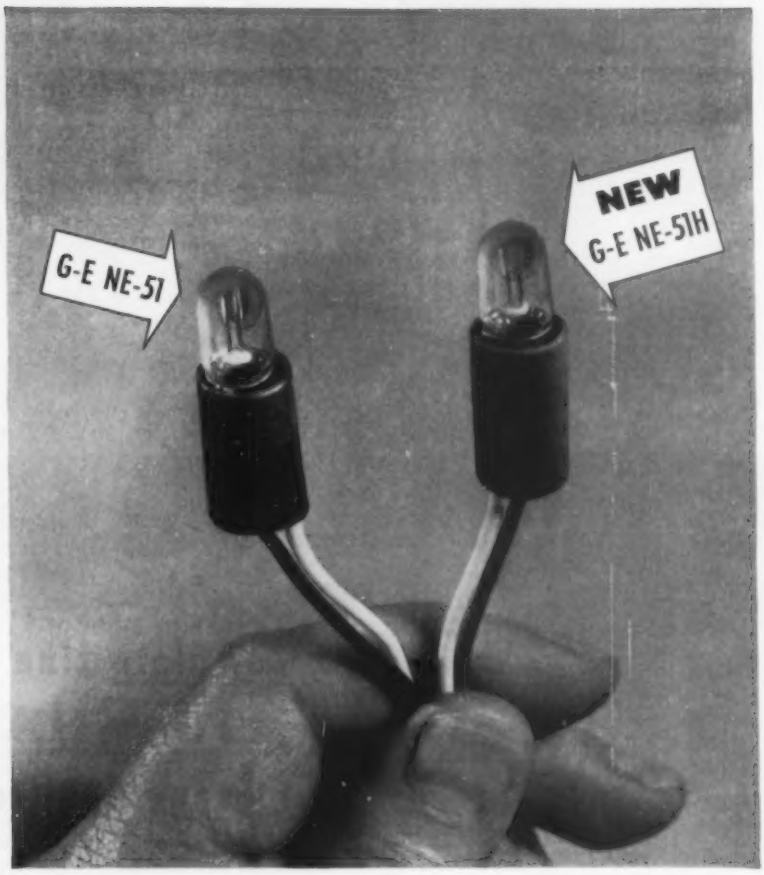
(Continued on page 94)



New G-E NE-51H glow lamp gives 20 times more light!

. . . without changing bulb size or shape!

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If you'd like more information on this versatile new G-E Glow Lamp, and how it can solve your indicator problems, write: General Electric Co., Miniature Lamp Dept. PE-118, Nela Park, Cleveland 12, Ohio.

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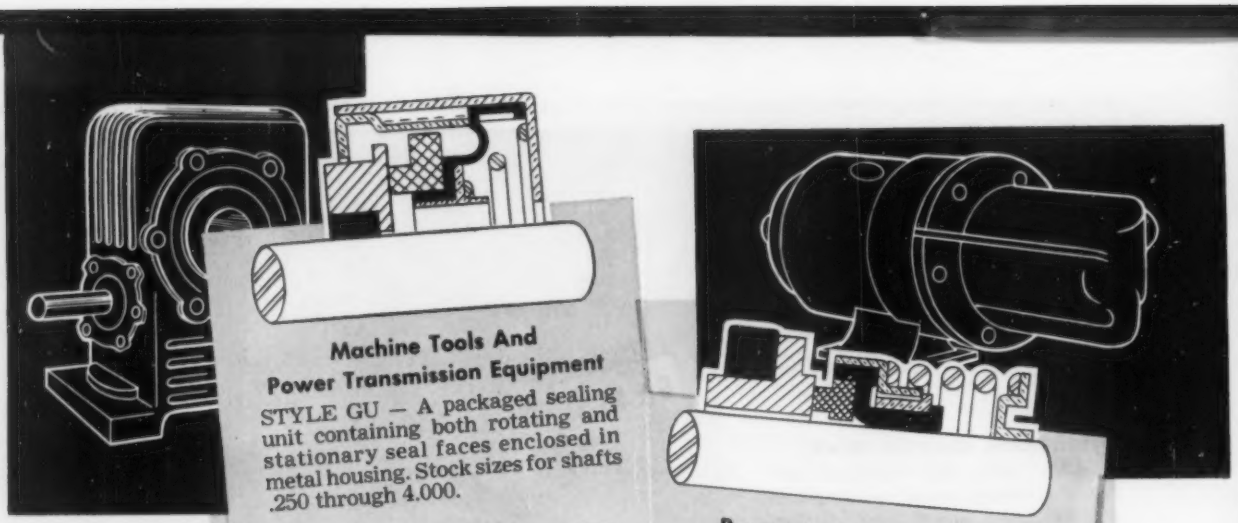

Machine Tools And Power Transmission Equipment

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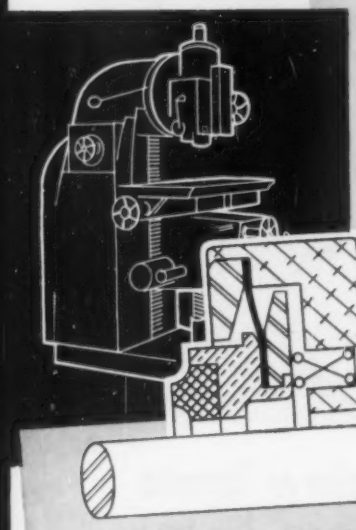

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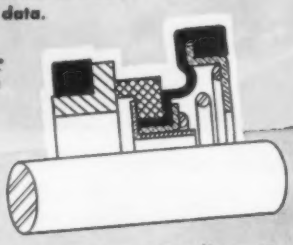

Household Appliances

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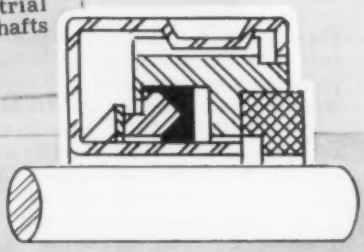
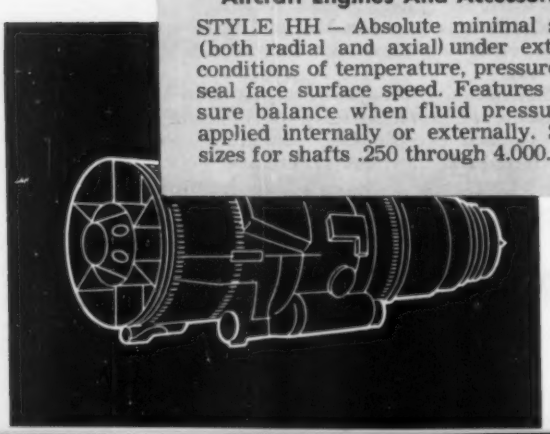


Aircraft Engines And Accessories

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.



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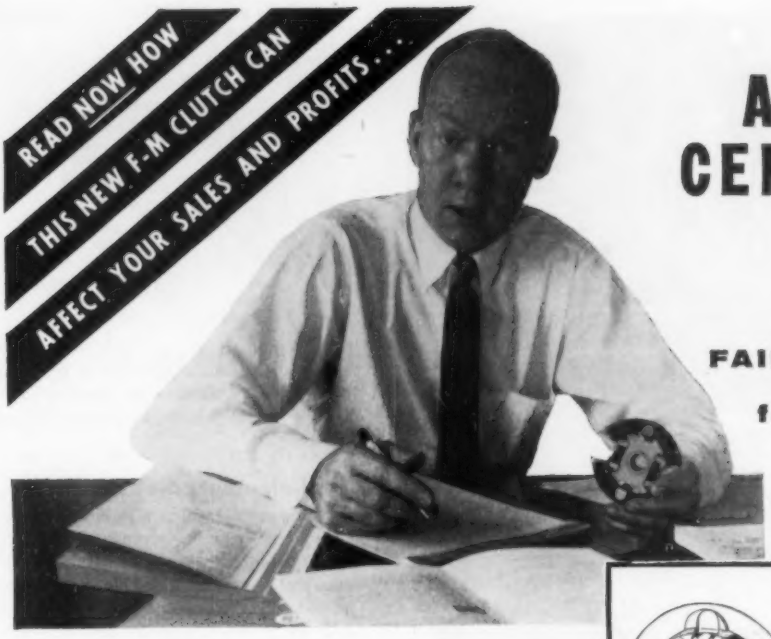

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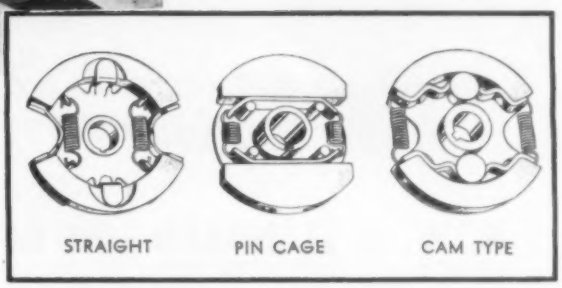

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Simple design and high-volume production of these new clutches for motors and small gasoline engines mean substantial savings to you. And your quantity requirements make little difference in the cost.

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- **Mounts in any position, as clutch or sheave**
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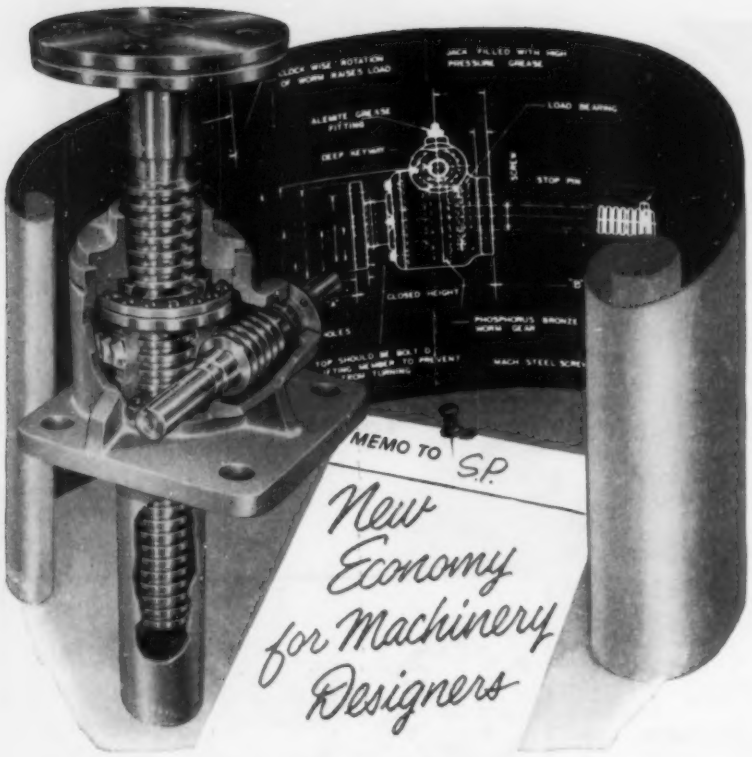


NOW, A STANDARD LINE OF DUFF-NORTON WORM GEAR JACKS

The economies of standardized production now can be realized by machinery designers who use Duff-Norton worm gear jacks for accurate positioning of loads weighing as much as several hundred tons. After 25 years of experience and hundreds of custom designs, Duff-Norton engineers have produced a standard line of eight jacks ranging from 2 to 100 tons in capacity which will meet almost any requirements. When jacks are used in an arrangement, added economy can be realized in raising unevenly distributed loads, since all models now have a uniform raise which permits jacks of varying capacities to operate in unison.

Worm gear jacks are purely mechanical devices, and they can hold heavy loads in position indefinitely without any creep. Functioning as components of machinery or equipment, they can raise or lower loads, apply pressure or resist impact. Worm gear jacks can be furnished with raises up to 24 inches, and they will provide exactly the same raise for years without adjustment.

Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting Bull. AD-66-DD, which includes drawings and full specifications.

DUFF-NORTON COMPANY

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

COFFING HOIST DIVISION • Danville, Illinois

DUFF-NORTON JACKS
Ratchet, Screw,
Hydraulic, Worm Gear

DUFF-NORTON

COFFING HOISTS
Ratchet Lever
Hand Chain, Electric

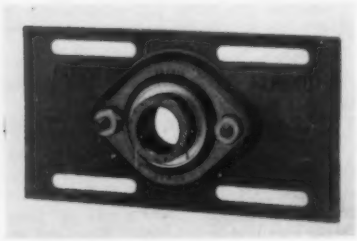
cal differentials are available for design layout work. **Arch Instrument Co, 101 Holmes St, N. Quincy 51, Mass.**

Circle 24, Reader Service Card

Dual-element potentiometer . . .

provides simultaneous control of two circuits by a single adjustment of a slotted shaft. Combines two potentiometers in one unit, measuring $\frac{7}{8}$ x $\frac{1}{2}$ x $1\frac{1}{2}$ in. Has metal-to-metal bond termination and is said to provide approximately a 100% usable potentiometer range. Mounts individually or in stacked assemblies. **Bourns Laboratories, PO Box 2112, Riverside, Calif.**

Circle 25, Reader Service Card



Ball bearing take-up unit . . .

is said to replace heavier, costlier types where excessive weight and capacity are not needed. Available in two basic sizes covering eight different shaft dimensions. Can be mounted by guide-type or bolt-type methods and accommodates misalignment without adjustment. Sealed and permanently prefabricated. **Fafnir Bearing Co, 37 Booth St, New Britain, Conn.**

Circle 26, Reader Service Card

Gearmotor line . . .

consists of single-, double- and triple-reduction units, integrally motor mounted, with motor capacities rated from 1 to 125 hp and output reduction speeds of 780 to $7\frac{1}{2}$ rpm. Available in standard open dripproof construction or totally enclosed fan-cooled and explosionproof. Standard electrical characteristics are normal torque, three or two-phase, 60 cps, 208, 220, 440 or 550 v. **Lima Electric Motor Co, Dept 145, Lima, Ohio.**

Circle 27, Reader Service Card

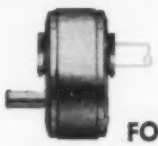
DETACHABLE MOTOR DESIGN
permits motor change in minutes
— avoids downtime for motor repairs.

Now - a MOTORIZED SPEED REDUCER FOR MOUNTING DIRECTLY ON SHAFT

the NEW BOSTON Gear® OPTIMOUNT TRADEMARK

IT'S THE NEW OPTIMOUNT

Ratiomotor for shaft mounting. It's the compact power package you have needed to save space without sacrifice of top transmission efficiency. Single or double reduction helical geared units deliver 87.4 to 431 output RPM. Get details—find out how OPTIMOUNT can solve your drive design problems.



HELICAL GEARED
REDUCTORS • RATIOMOTORS
AND FLANGED REDUCTORS

FOR SHAFT-MOUNTING . . .

OR IN STANDARD BASES FOR ANY FLOOR, WALL, OR CEILING MOUNTING POSITION

You can meet any drive conditions with OPTIMOUNT by using standard models *from stock*. Standardized, interchangeable parts permit easy adaptation to different drives. You save time in installation and maintenance, and reduce plant inventories of various types of speed reducers.

OPTIMOUNT delivers maximum power, with highest efficiency, through precision-finished helical gearing made to BOSTON Gear quality standards. Get details from your Distributor. He will demonstrate the many features that assure OPTIMUM PERFORMANCE. Boston Gear Works, 71 Hayward St., Quincy 71, Mass.

66 MODELS
FROM STOCK

680 OPTIONAL MOUNTING ARRANGEMENTS

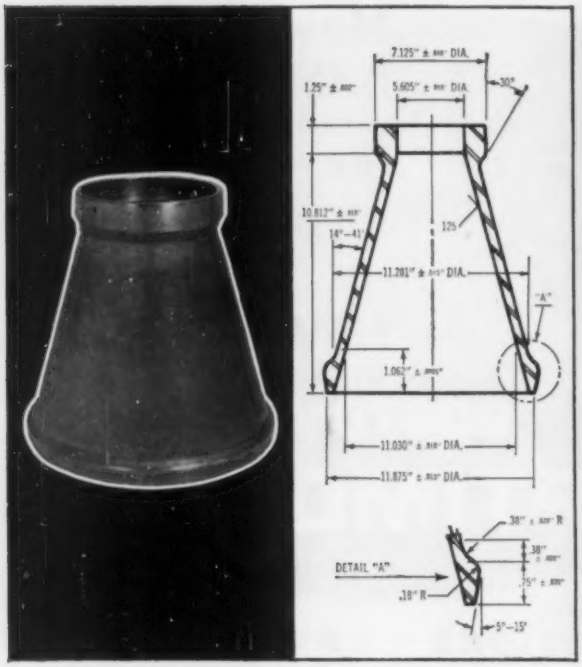
1/6 to 15 H.P. DRIVES

For nearest Distributor LOOK UNDER "GEARS" in the 'Yellow Pages'

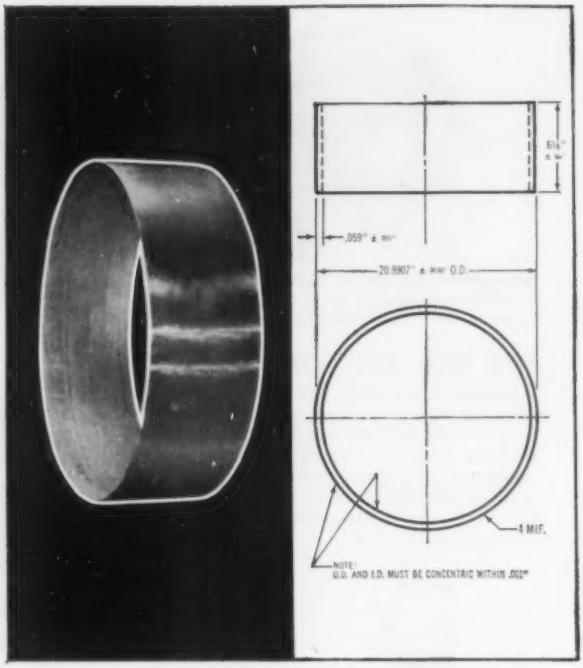
CALL YOUR BOSTON Gear DISTRIBUTOR

Remember — STANDARDIZATION PAYS —®

NEW CATALOG OP-1 lists complete OPTIMOUNT data—selection charts, application information.



STRAIGHT SIDE ROCKET CONE—Spun with tapered wall from 1020 steel blank: 18" diameter, 1" thick. Inside surface 125 MIF.



STRAIGHT WALL TUBE PRINTING BAND—Spun from ⅛" thick aluminum to .060" wall thickness, outside surface machine finished to 4MIF.

ROTOFORMS open new

ROTOFORMING reduces cost of unusual metal shapes—saves metal, eliminates machining and surface finishing

The design possibilities for hollow metal shapes are now unlimited. The most unusual metal custom parts can be practically and economically produced by ROTOFORMING.

This revolutionary new metal forming service now being offered by COMMERCIAL SHEARING & STAMPING displaces metal in a blank or preform. Rollers contacting the outside surface of the metal form it by high pressure as it rotates around a mandrel. The shape of the mandrel itself, at all times, controls the inside contour and size of the part.

WHAT SHAPES ARE POSSIBLE? Basically, ROTOFORMS can be grouped into four main categories: Straight-Side Cones, Straight-Wall Tubes, Curvilinear-Wall Shapes, and Elliptical or Hemispherical Shapes. Pictured above are representative ROTOFORMS already produced by COMMERCIAL. Principal dimensions are included.

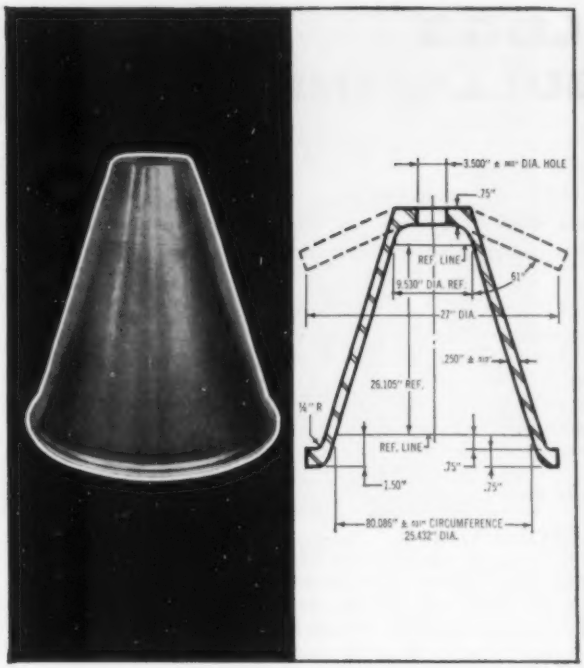
WHAT ABOUT SIZE AND WALL THICKNESS? The range of sizes for ROTOFORMS covers maximum diameters up to 42" down to a minimum tube I.D. of 2¼". Tube length can go as high as 100".

Steel blanks up to ¾" thick can be successfully handled by ROTOFORMING where conical shapes are involved. And when it comes to forming straight-wall tubes the wall thickness of steel blanks can even go up to ⅝". When forming metals more ductile than steel it is possible to work blanks with even greater wall thicknesses than those above.

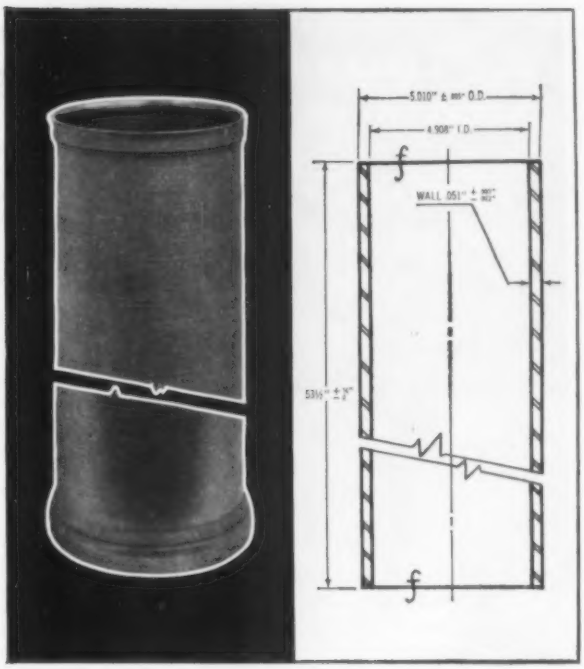
With ROTOFORMS wall thicknesses—both constant and variable—are feasible. Walls referenced to C/L can be straight, curved, or tapered. And ROTOFORMS have been successfully produced with a finished wall thickness no greater than $\frac{1}{32}$".

WHAT METALS CAN BE ROTOFORMED? A wide variety of carbon steels, stainless and special alloy steels, as well as aluminum, nickel, copper, molybdenum, magnesium and titanium alloys can be successfully ROTOFORMED. Even metal alloys such as 4130 steel, 1100-0 aluminum, and hard to machine Hastelloy, can and are being used in the regular production of ROTOFORMS.

WHAT HAPPENS TO THE METAL? The plastic deformation which metals undergo in the ROTOFORMING process elongates their grain structure and sub-



STRAIGHT SIDE MISSILE EXIT CONE—Spun with constant wall thickness from press pre-formed 1040 steel blank: 29" diameter, ¾" thick.



STRAIGHT WALL ROCKET TUBE—Spun from 4135 steel tubing (wall thickness ½") reduced to finished wall .051".

horizons for metal shape design!

stantially increases their strength. Tensile increases 1½ to 2 times, yield point is raised in even higher proportion, and fatigue strength is substantially improved. And ROTOFORMED parts can be heat treated to increase their ductility.

Because of the plastic deformation of metal, involved weld joints become unnoticeable when ROTOFORMED. And there are no hidden metal flaws in ROTOFORMS. Any metal inclusions or flaws in the parent metal are quickly uncovered during the ROTOFORMING process—appear as ruptures when pressure spinning rolls reposition the metal by physical displacement. Only 100% sound metal will produce successful ROTOFORMS.

WHAT ABOUT TOLERANCES AND FINISHES? Extremely close tolerances and tolerances commonly associated with fine machining are routine in the production of ROTOFORMS. It is not uncommon for ROTOFORMED parts taken from the machine as is to have inside diameters held to tolerances of +.000" −.003", +.005" −.000", and +.005" −.005".

Inside areas of ROTOFORMS finish to a glass-like surface—30 to 60 micro inch finishes being well within standard production practice. While outside surfaces finish to about 125 micro inch.

Because dimensional tolerances and inside surface finish have a direct relation to the variation and finish of blank from which the ROTOFORM is produced, when necessary the tolerances of a blank can be reduced and its finish improved beforehand in order to provide closer tolerances and a better inside finish in the actual ROTOFORM. In addition, the outside surfaces of ROTOFORMS can be brought to smoother finish by grinding, polishing or fine machining.

AN INVITATION FROM COMMERCIAL! This new metal forming process could be the practical and economical answer to your particular component problem. You can find out very quickly. Just a blueprint, sketch or prototype of your part in the hands of our engineers will bring you the complete cost-saving story—and at no obligation. Address inquiries to Commercial Shearing & Stamping Co., Dept. G-48 Youngstown 1, Ohio.

COMMERCIAL
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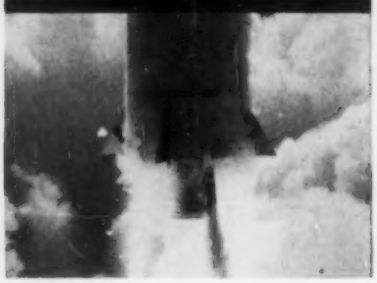
LINEAR ACCELEROMETER

RELIABILITY AND ACCURACY AT -65° F TO +200° F



The remarkable *gas-damping* feature of the Model A501 answers critical missile and aircraft testing demands for an accelerometer of accurate, reliable operation over a wide temperature range... *without the use of a heater jacket*. The Model A501 produces–flat up to 500 cycles per second–reliable signals for rapidly changing acceleration.

Range: ±5 to ±50 g
Excitation: 5 volts DC or AC (rms)
Output: ±20 millivolts
Non-linearity and Hysteresis:
Not more than ±1% full scale
Weight: 6½ ounces

For detailed technical data to answer your needs, write for Bulletin A501TC.

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accuracy / integrity / reliability

12401 W. Olympic Blvd., Los Angeles, Calif.

CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 102.

RELAYS—Catalog 1958-C9, 64 pp. Lists each major relay-manufacturer's line in alphabetical order, for purchasing reference and according to types or applications, for engineering and design reference. Provides circuit diagrams and dimensional drawings. Relay Sales, Box 186 PM, West Chicago, Ill.

Circle 28, Reader Service Card

CLEAR AND COLORED COATINGS–Brochure, 36 pp. Information on coatings for use on glass, metal, plastics and wood by spraying, screening and roller coating. Gives standard colors available, properties and application data on coatings. Bee Chemical Co, 12933 S Stony Island Ave, Chicago 33.

Circle 29, Reader Service Card

FHP SYNCHRONOUS MOTORS–Catalog EI-4, 28 pp. Includes data on over 200 motor designs, with particular emphasis on hyteresis motors. Theory and applications are provided for general reference. Specs on electrical, physical and performance characteristics are given in reference tables. Electric Indicator Co Inc, Camp Ave, Stamford, Conn.

Circle 30, Reader Service Card

ANTICORROSIVE FASTENERS–Stock list, 86 pp; Price list, 60 pp. The 1958, Third Quarter edition lists specs of more than 10,000 stock items, such as stainless steel nuts, bolts, pins and other fasteners. Anti-Corrosive Metal Products Co Inc, Castleton-on-Hudson, N Y.

Circle 31, Reader Service Card

FLEXIBLE TEFLON HOSE ASSEMBLIES–Bulletin TC-101, 16 pp. Describes and gives specs for available flexible hose assemblies of Teflon, complete with end fittings. Also, general information on properties, fabrication and facilities. American Metal Hose Div, American Brass Co, Waterbury 20, Conn.

Circle 32, Reader Service Card

INFRARED PHOTOCONDUCTORS–Technical bulletin 2, 12 pp. Describes types, characteristics and performance of lead sulfide detectors. Includes curves, photos and graphs. Infrared Industries Inc, P O Box 42, Waltham 54, Mass.

Circle 33, Reader Service Card

ADJUSTABLE-SPEED DRIVES—Bulletin GEA-6234B, 8 pp. Explains standard and optional features of general-purpose drives, 1-hp half-wave and 1 to 4-hp full-wave, electrical and performance characteristics, applications and key construction features of controller, dc motor and operator's control station. General Electric Co, Schenectady 5.

Circle 34, Reader Service Card

VARIABLE-SPEED DRIVES—Bulletin M-588, 8 pp. Describes and illustrates design features of drive that fulfills sanitary requirements of food and allied industries. Also includes condensed drive specs, assemblies and dimensions. Reeves Pulley Co, Div Reliance Electric & Engineering Co, Columbus, Ind.

Circle 35, Reader Service Card

GLASS FIBER INSULATION–Brochure WPD-13, 8 pp. Design brochure illustrates various types of insulations, with descriptions, features, uses, installation, thermal and acoustical performance, and standard items and facings available. Also, data on quartz microfibers for high-temperature insulation. LOF Glass Fibers Co, 1810 Madison Ave, Toledo 1, Ohio.

Circle 36, Reader Service Card

GLASS-SUPPORTED TEFLON TAPES, LAMINATES–Bulletin, 6 pp. Presents in tabular form a list of properties for standard and special grades, and discusses typical applications for each. Tables of sizes and tolerances are also included. Continental-Diamond Fibre Corp., Newark, Del.

Circle 37, Reader Service Card

HIGH-STRENGTH STEEL BARS–Bulletin, 4 pp. Gives properties, sizes, analysis and finishes of free machining steel that needs no heat treating. La Salle Steel Co, P O Box 6800-A, Chicago 80.

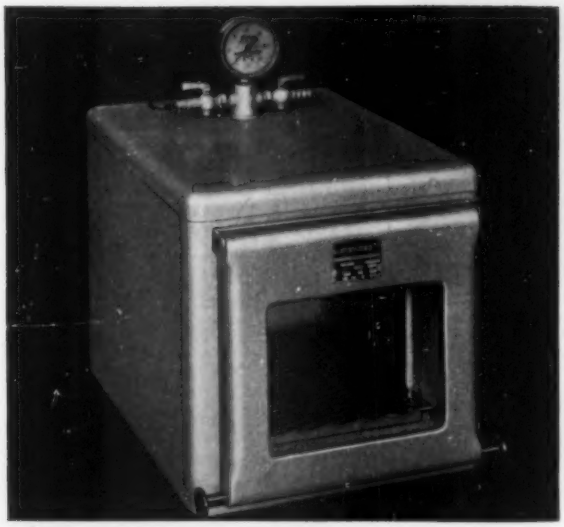
Circle 38, Reader Service Card

WEATHER-PROTECTED MOTORS–Bulletin 2550, 6 pp. Describes horizontal motors for outdoor operation under extreme weather conditions in ratings from 250 to 2000 hp. Cutaway views illustrate motor construction and design features. Motor specs are given, supplemented with dimensional drawings. Louis Allis Co, 427 E Stewart St, Milwaukee 1.

Circle 39, Reader Service Card

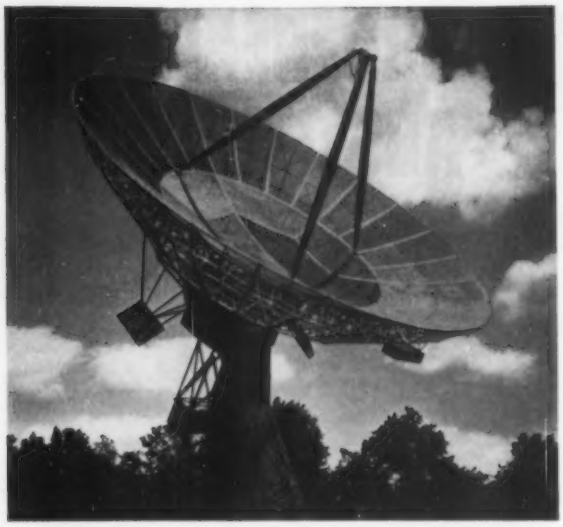
TWO-WAY AIR CONTROL VALVES–Bulletin F-44, 2 pp. Describes and illus-

(Continued on page 100)



CORROSION-RESISTANT SHELVING

Precision Scientific Company, manufacturers of laboratory ovens, puts corrosion resistance into shelving by making it from nickel-plated, Penmetal expanded metal. Shelving stays bright and clean through many years of service. It is strong, yet weighs next to nothing.

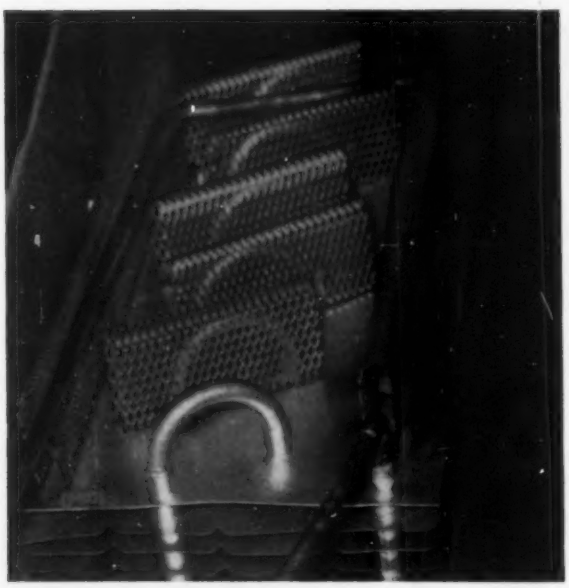


DURABLE ANTENNAE

D. S. Kennedy & Co., found Penmetal expanded aluminum the ideal material for the huge reflectors of their radio telescopes. Inherent structural strength helps prevent distortion with movement of the reflector... corrosion resistance provides 'round-the-clock weather protection.

3 PRODUCTS—3 ADVANTAGES

of Penmetal expanded metal



FUNCTIONAL COIL COVERS

Anheuser-Busch, Inc., St. Louis, uses Penmetal expanded aluminum in their freezing unit to cover exposed ends of evaporator coils. This provides extra prime surface for frost collection on the cooling coils and fins—increases efficiency of the units.

Here are three applications, typical of thousands in which Penmetal expanded metal has been used functionally to improve design. The wide range of valuable properties inherent in expanded metal makes it the ideal material for many, many jobs.

Up to 80% lighter than solid sheet of its own area, the diamond-truss pattern adds rigidity and strength. Gives free passage to heat, light, sound and air. Comes in carbon steel and corrosion-resistant metals.

Put Penmetal expanded metal to work for you. It will pay its own way and give you a good return on your investment. For full details, send for 28-page catalog 515-EM.

PENN METAL COMPANY, INC.

General Sales Office: 40 Central Street, Boston 9, Mass.

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Penmetal — METAL MADE OF QUALITY — 1869

a name to remember

PM-189

MICRO-BEARING ABSTRACTS

by **A. N. DANIELS**, *President*
New Hampshire Ball Bearings, Inc.

WHY CLASS ABEC 7 BEARINGS?

Improved Running Quality in critical applications is the reason why the Annular Bearing Engineers Committee of the Anti-Friction Bearing Manufacturers Association, Inc., has established Class 7 as the highest United States standard for manufacturing tolerances of miniature ball bearings. Originally available only on order . . . and at premium prices because of selection from ABEC 5 production runs . . . ABEC 7 bearings are now offered by New Hampshire Ball Bearings, Inc., as its minimum standard . . . at no extra charge.

An item-by-item comparison of ABEC 5 and ABEC 7 standards clearly shows how closer tolerances improve running quality.

(COMPARATIVE CHART)

RING		MEASUREMENT	TOLERANCES ABEC 5	TOLERANCES ABEC 7
Both	1.	Radial Runout (T1R) Max.	.0002"	.0001"*
Inner	2.	Side Runout with Bore	.0003"	.0001"
Outer	3.	O.D. Runout with Side	.0003"	.00015"
Both	4.	Parallelism of Sides	.0002"	.0001"
Inner	5.	Groove Parallelism with Sides	.0002"	.0001"
Outer	6.	Groove Parallelism with Sides	.0003"	.0002"
Inner	7.	Bore (I.D.)	+.00000" −.0002"	+.00000" −.00015"
Outer	8.	O.D.	+.00000" −.0002"	+.00000" −.00015"
Both	9.	Width (Individual Rings)	+.000" −.005"	+.000" −.001"**

*ABEC 7 allows .0002" radial runout for outer ring. We hold it to .0001".
**ABEC 7 allows −.005".

Radial Runout . . . the sum of a ring's out-of-roundness and eccentricity . . . is functionally important. In critical high-speed applications, it affects balance and true running. In precise gear trains, it affects backlash and sometimes angular velocity ratio. In closely designed synchros and similar electrical equipment, it affects air gap control. Since most bearings operate with inner ring rotation, you'll notice that ABEC 7 cuts the ABEC 5 allowance in half . . . from .0002" max. to .0001". For the outer ring ABEC 7 makes no change from Class 5's .0002" max. However, modern race grinders work to a nominal zero runout and .0001" max. may usually be expected. Our inspection tolerance, therefore, is .0001". This gives outer-ring rotation applications the same advantages as for inner-ring rotation.

Perpendicularity of raceway planes to axis of rotation is a highly desirable feature. Its probability is determined by the interrelationship of Side Runout with Bore (Inner Ring), O. D. Runout with Sides (Outer Ring), parallelism of sides and groove parallelism with sides of both rings, when bearings are properly mounted and seated. If raceway planes are not perpendicular to the axis of rotation, stresses and torque peaks will be developed within the bearing because of this misalignment unless radial clearance and enlarged raceway curvature are sufficient to compensate. This effect may be observed in clamped, preloaded duplex bearings by shifting the relative position of the rings, reclamping and feel-testing.

Notice that the five perpendicularity features (2 through 6 in the chart) have much lower allowances in ABEC 7 than in ABEC 5. These differences in angular inaccuracy mean much in running quality as bearings become smaller. For example, non-parallelism of .0002" on a ⅜" O.D. (R 2 bearing) represents an angular error of about 2 minutes. But, on a 3/16 O.D. (R 1 bearing), the same allowance means 4 minutes of angular error. That's why ABEC 7 reduces allowances by one half or more. The importance of minimizing angular error is also reflected in the AFBMA tables of allowances, which are generally reduced within each class as size of bearing is reduced.

Envelope Tolerances (7, 8, and 9 in the chart) make little or no difference in running quality. The only ABEC change is from bore tolerance of plus 0, minus .0002 in Class 5 to minus .00015 in Class 7. This permits mounting bearings to a narrower spread of fits. Although ABEC 7 allows the same O.D. and width tolerances as for ABEC 5, we have reduced O.D. tolerance to plus zero, minus .00015" and, together with other manufacturers of instrument bearings, have reduced width tolerance to minus .001. The latter minimizes variation in axial spacing of assemblies.

Other Factors that affect running quality of bearings are not covered by ABEC standards. They include: truth of raceway geometry, surface finishes, retainer design and finish, radial and axial play and some ball qualities. These are discussed in our design handbook.

DESIGN HANDBOOK OFFERED FREE

You'll find this up-to-the-minute, authoritative 70-plus-page publication a great help in designing instruments or small electromechanical assemblies. Write to New Hampshire Ball Bearings, Inc., Peterborough 1, N. H.

NEW HAMPSHIRE BALL BEARINGS, INC., PETERBOROUGH 1, NEW HAMPSHIRE

Catalogs and Bulletins . . . . . continued

trates bronze valve, including size and price data. OPW-Jordan, 6013 Wiehe Rd, Cincinnati 13.

Circle 40, Reader Service Card

MULTIPLE-POINT RECORDER CONTROLLER ASSEMBLY—Data sheet ND 46-33(6), 2 pp. Tells how assembly can be used for measurement and control of 6, 8, 12, 16, 20 or 24 thermocouple points. Simplified schematic illustrates operation. Includes specs. Leeds & Northrup Co, 4934 Stenton Ave, Philadelphia 44.

Circle 41, Reader Service Card

HYDRAULIC COMPONENTS FOR MOBILE EQUIPMENT—Bulletin 1502, 4 pp. Reviews directional control valves, accumulators, cylinders, hose assemblies and tube fittings. Parker Hydraulics Div, Parker-Hannifin Corp, 17325 Euclid Ave, Cleveland 12.

Circle 42, Reader Service Card

HIGH-STRENGTH, FLAME-RESISTANT LAMINATE—Technical data bulletin 4.5.1, 4 pp. Presents characteristics, property values, forms with dimensions for each, and suggested applications. Taylor Fibre Co, Norristown, Penna.

Circle 43, Reader Service Card

SILICON PHOTO-VOLTAIC CELLS—Bulletin 33-58, 4 pp. Design details, theory of operation, and application notes. Illustrated are typical current-voltage curves, variation of available power according to temperature changes, spectral response curves, and an enlarged view of cell section to show construction and operating details. Semiconductor Div, Hoffman Electronics Corp, 930 Pitner Ave, Evanston, Ill.

Circle 44, Reader Service Card

STATIC SWITCHING CIRCUITS—Bulletin 1058, 6 pp. Describes self-contained monitoring circuits that do not use relays or solenoids. Includes dimensions and ratings. Scam Instrument Corp, 1811 W Irving Park Rd, Chicago 13.

Circle 45, Reader Service Card

TOP HOLDING RETAINERS—Catalog 2-TT, 12 pp. Specs for three types of top holding retainers for tubes and components. With line drawings and dimensional diagrams. Birtcher Corp, Industrial Div, 4371 Valley Blvd, Los Angeles 32.

Circle 46, Reader Service Card

TRANSIT AND INSTRUMENT CASES—Catalog D, 12 pp. Lists standard lengths and widths plus max and min heights of each, available from existing tooling. Zero Mfg Co, 1121 Chestnut St, Burbank, Calif.

Circle 47, Reader Service Card

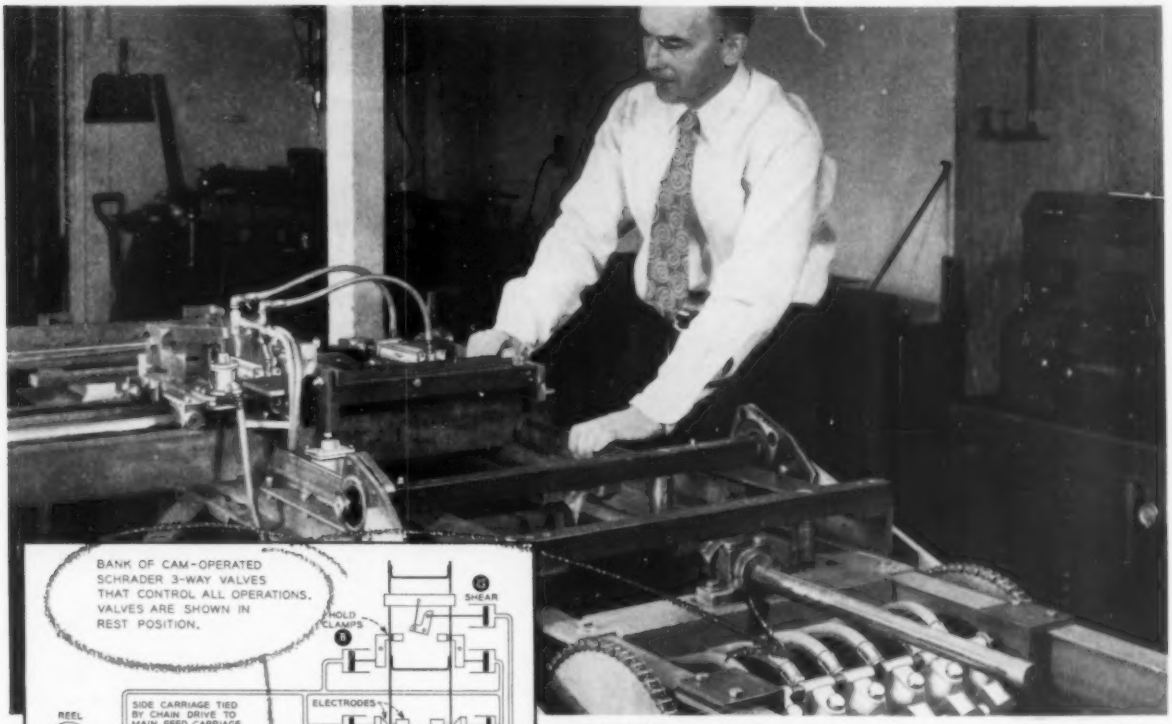
EXTRUDED TEFLON TUBES—Bulletin 158, 5 pp. Describes over 1000 sizes

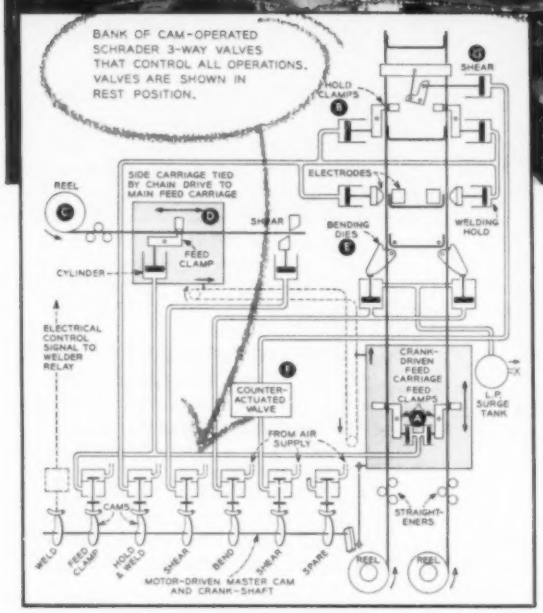
(Continued on page 102)

YOU, TOO, CAN AUTOMATE IT YOURSELF ...WITH SCHRADER AIR PRODUCTS

Very often you can automate manufacturing operations simply by applying Schrader air controls to existing plant facilities.

Here's a man with ideas who automated a complex job—increased production, reduced unit costs, safely and easily—without making a large capital investment. He did it with a planned Schrader air control system. Chances are excellent that you can do the same thing—with Schrader air products. Air can do an almost limitless range of work: automatic drilling, reaming, clamping and holding, shearing, forming, staking, grouping and interlocking assembly operations for quicker parts handling and assembly.





PROBLEM: Feed heavy wires into machine, shear off pieces, shape them, weld pieces together and eject as finished wire webbing. Fast. Economically. Automatically.

SOLUTION: Air Controls selected from Schrader's complete line. Neat bank of valves—actuated by cams on master cam shaft—operate synchronized system. Clamps A feed wires to holding Clamps B as carriage moves back and forth. Counter-actuated valve F operates cut-off shear G after desired number of cycles. Wire C, fed from carriage D, is sheared, formed by dies E, welded to the other two wires.

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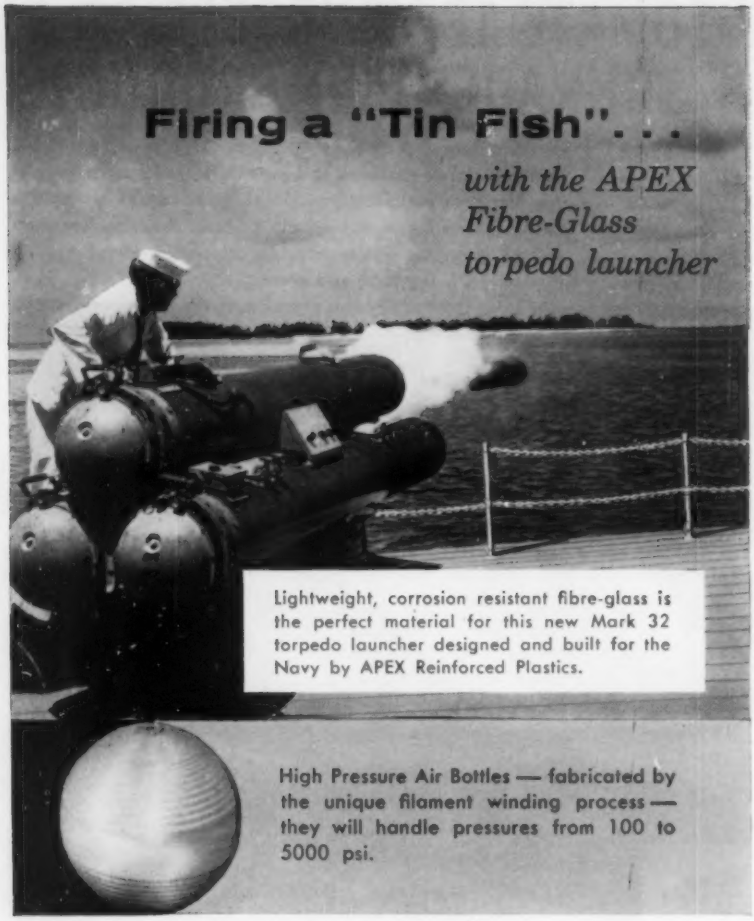
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STOCK MINIATURE TRANSFORMERS—Catalog, 10 pp. Describes transformers and related magnetic components for electronic applications at 380 to 1000 cps. Illustrated with dimensional and wiring diagrams. Gives electrical ratings and prices. Minitran Corp, 5 Oliver St, Newark 2, N J.

Circle 49, Reader Service Card

V-BELT DRIVES—Manual IP-1577, 12 pp. Tells how to select and install V-belts, how to detect trouble, diagnose failures and correct drive troubles. Lists tips for proper maintenance and suggested inventory survey for V-belt drives. BF Goodrich Industrial Products Co, Akron.

Circle 50, Reader Service Card

AUTOMATIC TENSION CONTROL—Brochure, 4 pp. Discusses operation of automatic tension control and how it can be applied. Mount Hope Machinery Co, 15 5th St, Taunton, Mass.

Circle 51, Reader Service Card

Letterhead Requests Only

Manufacturers who published following literature ask that requests for copies be made on company letterheads.

SPHERICAL ROLLER BEARINGS—Catalog 258, 48 pp. Covers five standard series of self-aligning bearings. Includes dimension tables, load ratings expressed as basic dynamic capacity, and line graphs showing modifying speed and life factors; 19 pp are devoted to general engineering information specifically related to spherical roller bearings. Torrington Co, Bantam Bearings Div, South Bend 21, Ind.

MAGNETIC AMPLIFIERS — Bulletin 1105-1, 36 pp. Construction, operation and uses of magnetic amplifiers are presented in text and diagrams. Cutaway and exploded views illustrate design and construction. Performance curves indicate operating characteristics. Simplified schematics show how amplifier is incorporated into equipment. Vickers Inc, Electric Products Div, 1815 Locust St, St Louis 3.

SINTERED BEARINGS AND PARTS—Catalog, 68 pp. Includes classification and application data, dimensional tolerances, specifications of the parts available and properties of material used, standard bearing sizes, and microphotographs to show metal structure. Also, a bibliography of articles published on powder metallurgy. Wakefield Bearing Corp, 29-99 Foundry St, Wakefield, Mass.

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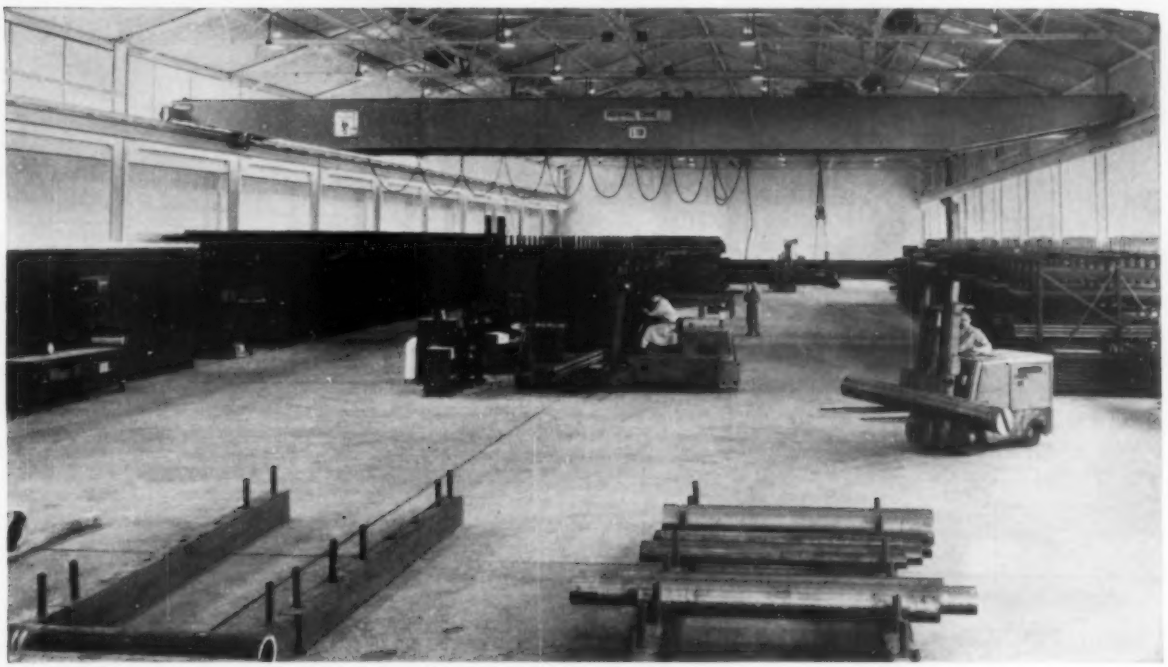

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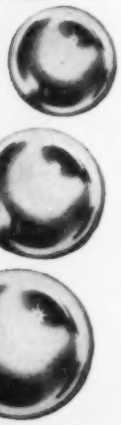

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ABSTRACTS DESIGN

NLGI Annual Meeting, Oct. 27-29, Chicago

For copies of papers write NLGI, 4638 J C Nichols Pkwy, Kansas City 12, Mo.

Developments and Trends in Gear Lubrication

As gear design has been modified to meet modern requirements, lubricants have likewise progressed, and in recent years this has been primarily accomplished by the use of additives to petroleum oils. These additives have provided a considerable increase in anti-wear and improved film formation between contacting surfaces.

It has been common knowledge for many years that both pressure and temperature greatly affect the viscosity of an oil. The relationship between temperature and viscosity is quite common knowledge and used extensively today. Considerable thought is being given by ASTM and other technical groups to a uniform method of measuring pressure-viscosity. With the increased loadings on gear teeth, the pressure-viscosity relationship becomes more important.

"Recent Developments and Trends in Industrial Gear Lubrication," E S Reynolds, Socony Mobil Oil Co Inc.

Extreme-pressure Greases

The current technology concerning extreme-pressure and high-temperature greases for the 65 to 400-F temperature range is reviewed. A series of additives which overcome the disadvantages of known extreme-pressure additives are discussed. Resistance to corrosion and decomposition at high temperatures was a major factor in the selection of the final additive system. Numerous greases with mean Hertz loads of 50 or greater have been produced, using various members of this additive system. Various homologous series can be shown to have unexpectedly beneficial results in comparison with other members of this series. The grease developed during this project is a blend of silicone fluids, a polyester fluid and an aryl substituted urea used as a thickener. This grease has been successfully tested as high as 400 F and as low as −90 F.

"Development of Extreme Pressure Greases," R K Smith, E F Houghton & Co.

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Insert and Set From Same Side
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High Clinching Action
Pulls parts together with up to 600 lbs. squeeze. Eliminates need to clamp.

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Where space is important, "POP" Rivets' minimum head height eliminates clearance problems and improves appearance.

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- **Installed and set from same side**

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"POP" Rivets are precision made, hollow rivets assembled on a solid high tensile mandrel. The setting tool pulls the mandrel head into the rivet from the front side, setting the rivet on the reverse side. Mandrel breaks under tension of up to 1600 lbs. and falls free.

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WHY? Because dependable 2000 psi Denison hydraulic power helps Caterpillar build *lower operating cost* and continuous, troublefree performance into its rugged earth-moving units.

Case in point: Here's Caterpillar's No. 9 Ripper—another of many construction units to be factory-equipped with Denison hydraulic equipment. The Ripper's hardworking teeth are powered by a single Denison vane-type pump which provides plenty of reserve "go" for toughest workloads.

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NEW BOOKS

Fluid Dynamics and Heat Transfer

JAMES G KNUDSEN AND DONALD L KATZ. Published by McGraw-Hill Book Co, 330 W 42nd St., New York 36. 6¼ x 9¼, 576 pp. $12.50.

Here is a text bridging the gap between fluid flow and heat transfer. Although aimed at a graduate level, material is developed from fundamentals of fluid flow and heat transfer to practical applications in equipment design. Fluid dynamics is discussed extensively in the first 11 chapters—laminar and turbulent flow in closed conduits, laminar and turbulent flow past immersed bodies, flow in heat exchangers. This background is essential to an understanding of convection heat transfer, discussed in the concluding six chapters.

New material in this book includes: liquid-metal heat transfer, recent studies of flow in entrances, and much of the recent material on the analogy between fluid flow and heat transfer. Typical problems for each chapter are appended.

Strain-gage Techniques, I and II

WILLIAM M MURRAY, ScD, and PETER K STEIN, SM. University of California at Los Angeles, Dept of Engineering. 8½ x 11, 657 pp.

These are a series of lectures presented at UCLA in Aug 1957 with the joint sponsorship of the SESA. The booklets are in two parts and start with a general survey of fundamental requirements and concepts. All phases of strain-gage techniques are covered and the results of 26 separate experiments are included. It is intended that these two booklets eventually will be the basis for a book.

Engineering Vibrations

LYDIK S JACOBSEN AND ROBERT S AYRE. Published by McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 9 x 6, 564 pp. $10.

This introduction to the analysis of technical vibrations of linear and nonlinear systems is intended for the practicing engineer and the student. In

(Continued on page 109)

view of the modern interest in shock problems, the book emphasizes the transient state of motion and considers the steady state a special one. However, many important technical cases of steady state vibration are included.

Since the book features a strong physical intuitive rather than mathematical approach, no more than a beginning knowledge of differential equations is required. Classical analytical methods are used where feasible, and extensive use is made of approximate methods, including the phase-plane graphical method for the step-by-step solution of transient problems in both linear and nonlinear systems and the Ritz averaging method for solving steady state nonlinear problems.

The authors introduce many applications in the vibration of machines and structures: They emphasize the setting-up and solution of differential equations of motion for a wide variety of vibrating systems, including nonlinear systems subjected to transient disturbances. Attention is given to the physical aspects of vibration problems, and nonlinear relationships are introduced in many cases.

The book contains over 150 solved examples.

Industrial Control Circuits

SIDNEY PLATT. Published by John F Rider Inc, 116 W 14th St, New York 11. 5½ x8½, 194 pp. $3.90.

This is a simplified practical book which leaves out mathematics and complex theory and explains the operation of simple vacuum-tube and common electronic circuits. There are chapters on electronic relay control and timing circuits, photoelectric control, power controls, control circuits for gaseous and vapor-filled tubes, electronic dc motor control, welding control, and industrial instrumentation control. This is a book for a mechanical engineer who finds himself involved in choosing electronic components.

Logic Machines and Diagrams

MARTIN GARDNER. Published by McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 9 x 6, 157 pp. $5.

Here is a complete survey of mechanical and electrical machines designed to solve problems in formal logic, and of geometrical methods for doing the same thing.

The book begins with the eccentric logic of the Spanish mystic, Ramon Lull; goes through the fascinating history of logic diagrams and machines; and concludes with the complex, efficient electrical machines of today.

Much of this material is published here for the first time. For instance, one will find some unfamiliar uses for the well-known Venn circles, an explanation of an original network diagram for solving problems in the propositional calculus, a popular exposition of the new binary method of handling the calculus, and instructions for making cardboard devices that quickly identify valid syllogisms or show the formal fallacies of invalid ones.

The Stanhope demonstrator, Jevons' Logic machine, the Marquand machine, and others are well described and illustrated, and logic window cards—easily constructed cards for solving elementary logic problems—are explained.

Later chapters in the book bring you a thorough discussion of electrical logic machines, emphasizing the growing utility of such devices in an automated age. Future applications of logic machines to such fields as operations research, information storage and processing, and efficient circuit designing, are outlined and discussed.

Properties of Gases and Liquids

ROBERT C REID AND THOMAS K SHERWOOD. Published by McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 9 x 6, 386 pp. $10.

This book presents a critical review of the methods useful in correlating or estimating the more important physical properties of pure materials and simple mixtures.

Each property is first discussed from a theoretical standpoint. Following this, both theoretical and empirical methods of estimating the property for new substances are discussed and compared with data. Methods of extrapolation of experimental data to unexplored ranges of such variables as temperature and pressure are also presented.

The book treats estimation of the following properties: critical pressure,

(Continued on page 112)

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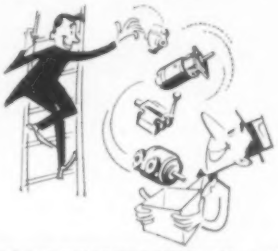

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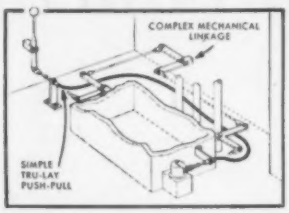

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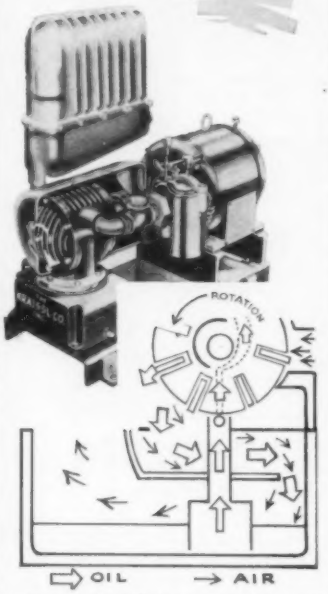

Improved efficiency and longer pump life are of constant concern to designer, production engineer and purchasing agent. You get both from Kraissl air pumps—with our patented force-feed system of lubrication.

Exclusive design uses the pump's differential pressure to insure abundant oil supply to all moving parts. This reduces air slippage and flushes oxidation products from bearing surfaces; it keeps lubricating film between all contacting parts—and minimizes temperatures on moving surfaces.

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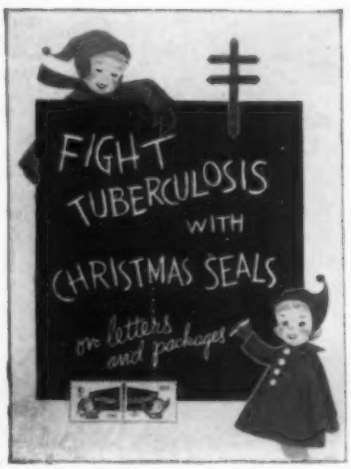

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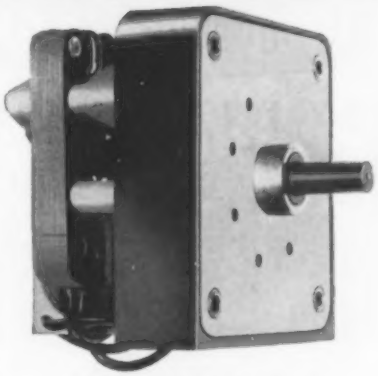

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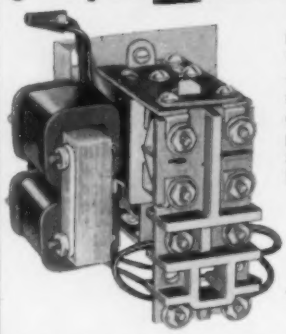

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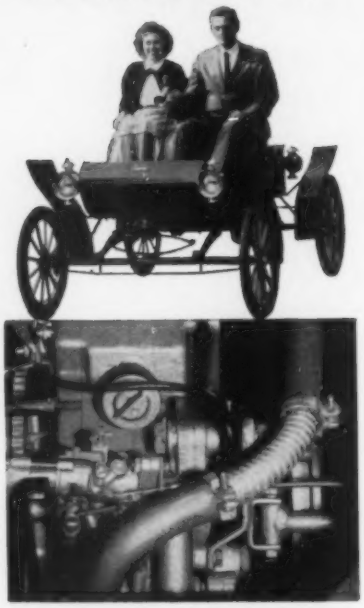

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INDEX OF PRODUCTS
ADVERTISED IN THIS ISSUE

After reading the advertisements classified below . . . MORE DETAILED INFORMATION about these products can be obtained by using the READER SERVICE CARD

A

Actuators
Mechanical 86
Adhesives 14-15

B

Balls 106
Bars
Metal 2, 38, 52
Bearings
Ball 50, 83, 85, 100, 115
Jewel 86
Miniature 114
Needle 83
Roller 83, 114
Sleeve 106
Belts, V 14-15
Bolts 48

C

Cams 90
Carbon ..... 4th Cover
Clad Metals 16
Clips 114
Clutches
Mechanical 93
Coatings 14-15, 76
Connectors
Hose 35-36
Tube 35-36
Contactors 29-30
Controls
Electrical 34, 78
Hydraulic 108-109
Mechanical 112
Pneumatic 101
Conveyor Belts 14-15
Cylinders
Hydraulic 35-36
Pneumatic 35-36

D

Decalcomanias 90
Die Castings 9-11
Drafting
Machines 110-111
Supplies 45, 110-111, 115

E

Enclosures 112
Engineering Services (see also Production Services) 40-41
Expanded Metals 99
Extrusions
Metallic 96-97
Nonmetallic 14-15

F

Fabricated Plastics (see Plastics, Fabricated)
Fabricated Steel (see Sheet Fabricated, Structural Forms & Shapes, Weldments)
Fastening Methods 107
Fibre-glass 102
Filters
Air 35-36
Hydraulic 35-36
Fittings, Hose, Pipe & Tube 35-36
Forgings 46

G

Gaskets 112, 117
Gear Motors (see also Motor Reducers) 113, 119
Gears ..... 2nd Cover, 43
Graphite ..... 4th Cover

H

Heating Units 112
Hose & Tubing 31

J

Jacks 94
Jewels 86
Joints
Universal 88

L

Lamps, Indicator 91
Laminated Plastics (see Plastics, Laminated)
Liquid Level Controls 114
Lubricants 76

M

Metal Bonded to Plastic 106
Metal Forming 96-97
Moldings
Plastic (see Plastic Parts)
Rubber (see Rubber Parts)
Molybdenum Alloys 6
Motor Starters 29-30, 78, 119
Motors, A-C
Fractional 17-20, 39, 119
Integral 17-20, 119
Motors, D-C
Fractional 17-20, 39, 106, 119
Integral 17-20, 106, 119
Sub-Fractional 106
Motors, Hydraulic 108-109

N

Name Plates 90
Nuts 48

P

Packings 14-15, 117
Photographic Equipment
Film 45
Paper 45
Pillow Blocks 85
Plastic Parts 37, 42
Plastics 37, 87, 104-105, 106
Plastics Fabricated 102
Plates 52
Porcelain 32-33
Powdered Metal Parts ..... 4th Cover
Production Services (see also Engineering Services) 9-11
Pumps
Air 113
Liquid 108-109, 113

R

Regulators
Hydraulic 35-36
Pneumatic 35-36, 101
Reproduction Equipment 45, 110-111
Reproduction Supplies 45, 110-111
Resins 37, 104-105
Rivets 107
Rubber 89, 120
Rubber Parts ..... 3rd Cover, 14-15, 120
Rust Proofing 76

S

Screws 48
Seals 14-15, 92, 112
Servomechanism Components 90
Shapes, Roll Formed 38
Sheets
Metal 2, 52, 80
Plastic 42
Special Shapes & Sections 38
Specialty Fasteners (Pipe Hangers, Special Cold Headed Parts, etc.) 48
Speed Increasers & Reducers ..... 2nd Cover, 95
Springs 40-41
Steel
Alloy 12-13, 38, 103
Coated 2, 44
Carbon 12-13
Stainless 2, 12-13, 52, 80
Strip, Metallic 2, 52, 80
Switches 73

T

Testing Machines & Equipment 98
Thermostats 4
Timers 8
Timing Motors 8
Tubing
Flexible Metal 31, 114
Seamless 103
Welded 2

V

Valves
Air 35-36, 101
Hydraulic 35-36, 47, 108-109

W

Wear Materials 16
Wire 2
Wire Cloth 1

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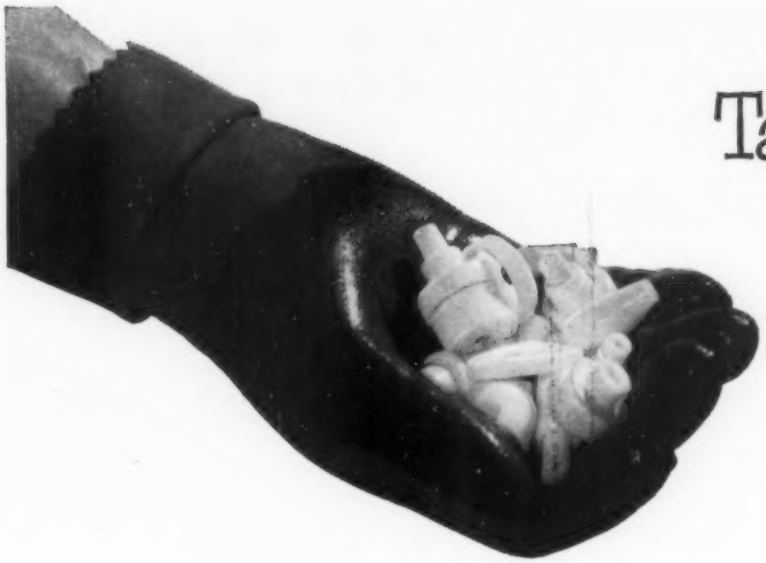

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INDEX TO ADVERTISERS

This index is published as a convenience to the readers. Every care is taken to make it accurate but PRODUCT ENGINEERING assumes no responsibilities for errors or omissions

A

Acro Div., Robertshaw-Fulton Controls Co. 73
Allegheny Ludlum Steel Corp. 52
Allen-Bradley Co. 29-30
American Metal Hose Div., American Brass Co. 31
American Steel & Wire Div., U. S. Steel Corp. 40-41
Apex Reinforced Plastics Div., White Sewing Machine Corp. 102
Armco Steel Corp. 2
Automotive & Aircraft Div., American Chain & Cable Co. 112

B

Bakelite Corp., Div., Union Carbide Corp. 104-105
Bird & Co., Inc., Richard H. 86
Boston Gear Works 95
Bruning Co., Inc., Charles ..110-111, 115

C

Chicago Molded Products Corp. 42
Cleveland Worm & Gear Co. ..... 2nd Cover
Climax Molybdenum Co. 6
Commercial Shearing & Stamping Co. 96-97
Cramer Controls Corp. 8
Cutler-Hammer, Inc. 78

D

De Laval Steam Turbine Co. 43
Denison Engineering Co., Subs., American Brake Shoe Co. 108-109
Dixon Corp. 106
Doehler-Jarvis Div., National Lead Co. 9-11
Duff-Norton Co. 94
Durez Plastics Div., Hooker Chemial Corp. 37

E

Eastern Air Devices, Inc. 90
Electro-Flex Heat, Inc. 112

F

Fairbanks, Morse & Co., Magneto Div. 93

G

Gear Grinding Machine Co., Joint Div. 88
General Electric Co., Apparatus Dept. 106
General Electric Co., Miniature Lamp Dept. 91
Gits Bros. Mfg. Co. 92

H

Hartford Steel Ball Co. 106
Heinze Electric Co. 113
Hoover Ball & Bearing Co. 85

J

Johns-Manville Corp. 117

K

Kaydon Engineering Corp. 83
Kraissl Co. 113

L

Landis & Gyr, Inc. 115
LimiTorque Corp., Philadelphia Gear Corp. 86

M

McLouth Steel Corp. 80
Meyercord Co., Name Plate Div. 90
Minneapolis-Honeywell Regulator Co. 34
Minnesota Rubber Co. ..... 3rd Cover
Mueller Brass Co. 46
Mueller Electric Co. 114

N

National Aniline Div., Allied Chemical & Dye Corp. 87
National Standard Co. 1
New Departure Div., General Motors Corp. 50
New Hampshire Ball Bearings, Inc. . 100

O

Ohio Knife Co., The 16
Ohio Rubber Co. 120

P

Parker Hannifin Corp., Parker Fittings & Hose Div. 35-36
Parker Rust Proof Co. 76
Pennsylvania Flexible Metallic Tubing Co. 114
Penn Metal Co., Inc. 99
Philadelphia Gear Corp. 86
Porcelain Enamel Institute, Inc. 32-33

R

Raybestos-Manhattan, Inc. 14-15
Recordak Corp., Subs., Eastman Kodak Co. 45
Robbins & Myers, Inc. 39
Rockwood Sprinkler Co. 47
Rowbottom Machine Co. 90
Russell, Burdsall & Ward Bolt & Nut Co. 48

S

Schrader's Son A., Div., Scovill Mfg. Co., Inc. 101
Smith Corp., A. O., Electric Motor Div. 17-20
Statham Instruments, Inc. 98
Stevens Mfg. Co. 4

T

T A Mfg. Corp. 112
Thiokol Chemical Corp. 89
Timken Roller Bearing Co., Steel & Tubes Div. 103

U

United Shoe Machinery Corp. 107
U. S. Graphite Co., Div. of the Wickes Corp. ..... 4th Cover
U. S. Steel Corp. 12-13, 38

V

Vellumoid Co. 112

W

Wagner Electric Corp. 119
Warrick Co., Charles F. 114
Weirton Steel Co., Div., National Steel Corp. 44

PRODUCT ENGINEERING
ADVERTISING SALES STAFF

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F. J. Eberle, Business Mgr.
EMPLOYMENT OPPORTUNITIES. 116
Index to Advertisers appears on P. 118
Products Index appears on P. 116

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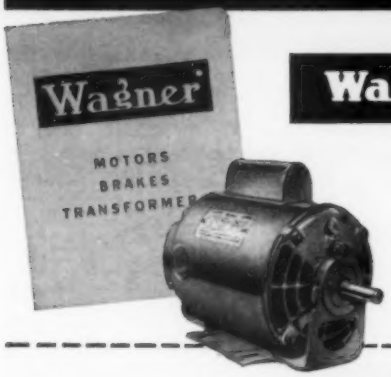

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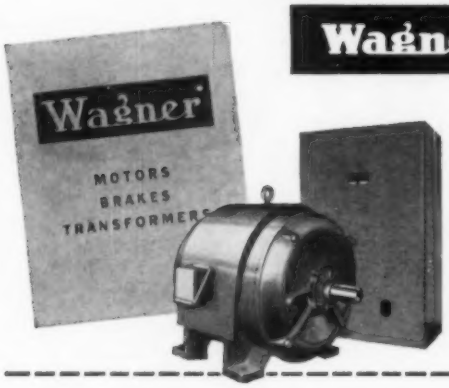

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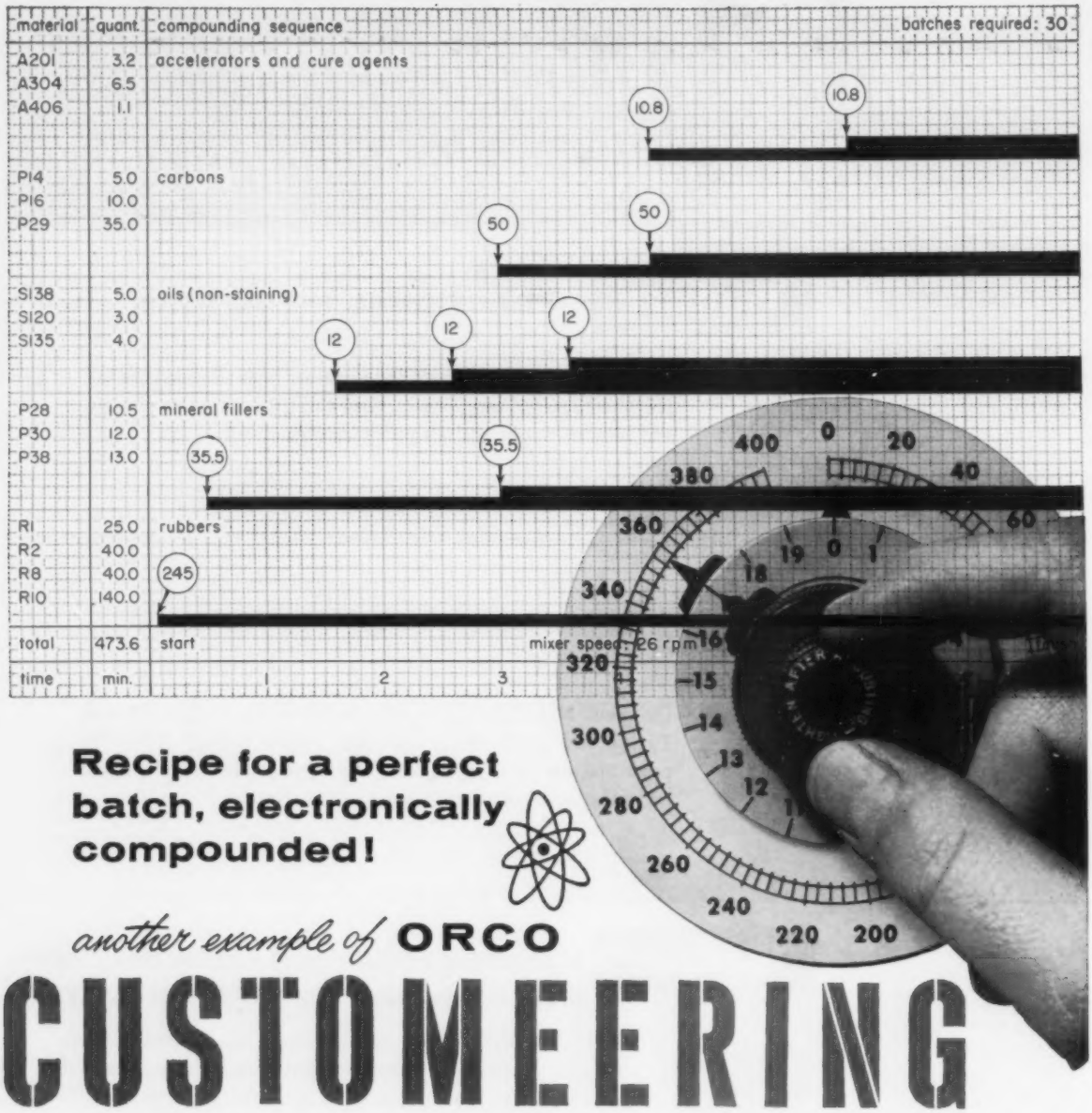

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E39. Selecting Polyphase Motors—Tables match drive-load characteristics with available motor designs in terms of torque, slip and duty cycle (8/18/58)

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E43. Three New Rigid Thermoplastics—Delrin, Lexon and Pro-fax are compared with curves and tables (9/29/58)

E44. Optical Projectors—How projectors may be used in development, research and laboratory testing. Chart gives limitation and advantages of 30 conditions. Design Digest 1958

E45. Numerical Control of Machine Tools—How it works; where it's heading (10/27/58)

E46. Microfilm—How miniaturization can solve management's problems and ease design work (10/27/58)

E47. Which Tachometer for Measuring RPM?—Rotational speed can be clocked with many devices. Selection chart matches the method to the need (11/10/58)

E48. Springs That Store Energy Best—Theory and tables show why reinforced plastic is better than a standard helical or cantilever (11/10/58)

E49. Tap the Reserve Strength in Metal—Charts and formulas for determining how far beyond the yield strength you dare go (9/29/58)

E50. Electromagnetic Relays—Cost analysis of switching devices (11/24/58)

E51. Porcelain Enamel—New look at wide selection of colors and textured surfaces available. Charts describes enamelling processes (11/24/58)

NEW COMPONENTS DESCRIBE

NON-METALLIC MATERIALS, FINISHES
4—Clear Anodize for Magnesium

POWER TRANSMISSION
2—Multiple-plate Clutches
6—Over-running Clutch
10—Disk-type Electric Clutches
18—Nonlubricated Coupling
24—Hollow-shaft Differentials
27—Gearmotor Line

MECHANICAL PARTS
7—Teflon Ribbon Cable
13—Contour Cushion Seat
26—Ball-bearing Take-up Unit

FASTENING AND JOINING
1—Vibration-resistant Fastener
9—Welder for Thermoplastics
12—Polyethylene Wire-ties

MOTORS, ENGINES AND CONTROLS
11—Fhp Control Motor

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8—Miniature Fluorescent Lights
14—Mechanically-held Relays
15—High-speed Solenoid
16—Miniature Circuit Breaker
19—Noble Metal Contacts
25—Dual-element Potentiometer

HYDRAULIC, PNEUMATIC EQUIPMENT

3—Quick-coupling Fine Filters
5—Psia Transmitter
17—Hydraulic Check Valves
20—Pilot-operated Relief Valve
21—Gearcase Oil Gages
22—Nylon-body Solenoid Valve
23—Pressure Transducer

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CATALOGS AND BULLETINS OFFERED IN THIS ISSUE

METALS AND ALLOYS

38—High-strength Steel Bars, 4 pp, La Salle Steel Co.

NON-METALLIC MATERIALS, FINISHES

29—Clear and Colored Coatings, 36 pp, Bee Chemical Co.
36—Glass Fiber Insulation, 8 pp, LOF Glass Fibers Co.
37—Glass-supported Teflon, 6 pp, Continental-Diamond Fibre Corp.
43—High-strength, Flame-resistant Laminate, 4 pp, Taylor Fibre Co.

POWER TRANSMISSION

34—Adjustable-speed Drives, 8 pp, General Electric Co.
35—Variable-speed Drives, 8 pp, Reeves Pulley Co.
50—V-belt Drives, 12 pp, BF Goodrich Industrial Products Co.

MECHANICAL PARTS

47—Transit and Instrument Cases, 12 pp, Zero Mfg Co.
48—Extruded Teflon Tubes, 5 pp, Surf Chemical Inc.
51—Automatic Tension Control, 4 pp, Mount Hope Machinery Co.

FASTENING AND JOINING

31—Anticorrosive Fasteners, 86 pp, Anti-Corrosive Metal Products Co Inc.
46—Top Holding Retainers, 12 pp, Birtcher Corp, Industrial Div.

MOTORS, ENGINES AND CONTROLS

30—FHP Synchronous Motors, 28 pp, Electric Indicator Co Inc.
39—Weather-protected Motors, 6 pp, Louis Allis Co.

ELECTRICAL, ELECTRONIC COMPONENTS

28—Relays, 64 pp, Relay Sales
33—Infrared Photoconductors, 12 pp, Infrared Industries Inc.
41—Multiple-point Recorder Controller, 2 pp, Leeds & Northrup Co.
44—Silicon Photo-voltaic Cells, 4 pp, Hoffman Electronics Corp.
45—Static Switching Circuits, 6 pp, Scam Instrument Corp.
49—Stock Miniature Transformers, 10 pp, Minitran Corp.

HYDRAULIC, PNEUMATIC EQUIPMENT

32—Flexible Teflon Hose Assemblies, 16 pp, American Metal Hose Div, American Brass Co.
40—Two-way Air Control Valves, 2 pp, OPW-Jordan
42—Hydraulic Components for Mobile Equipment, 4 pp, Parker Hydraulic Div, Parker-Hannifin Corp.

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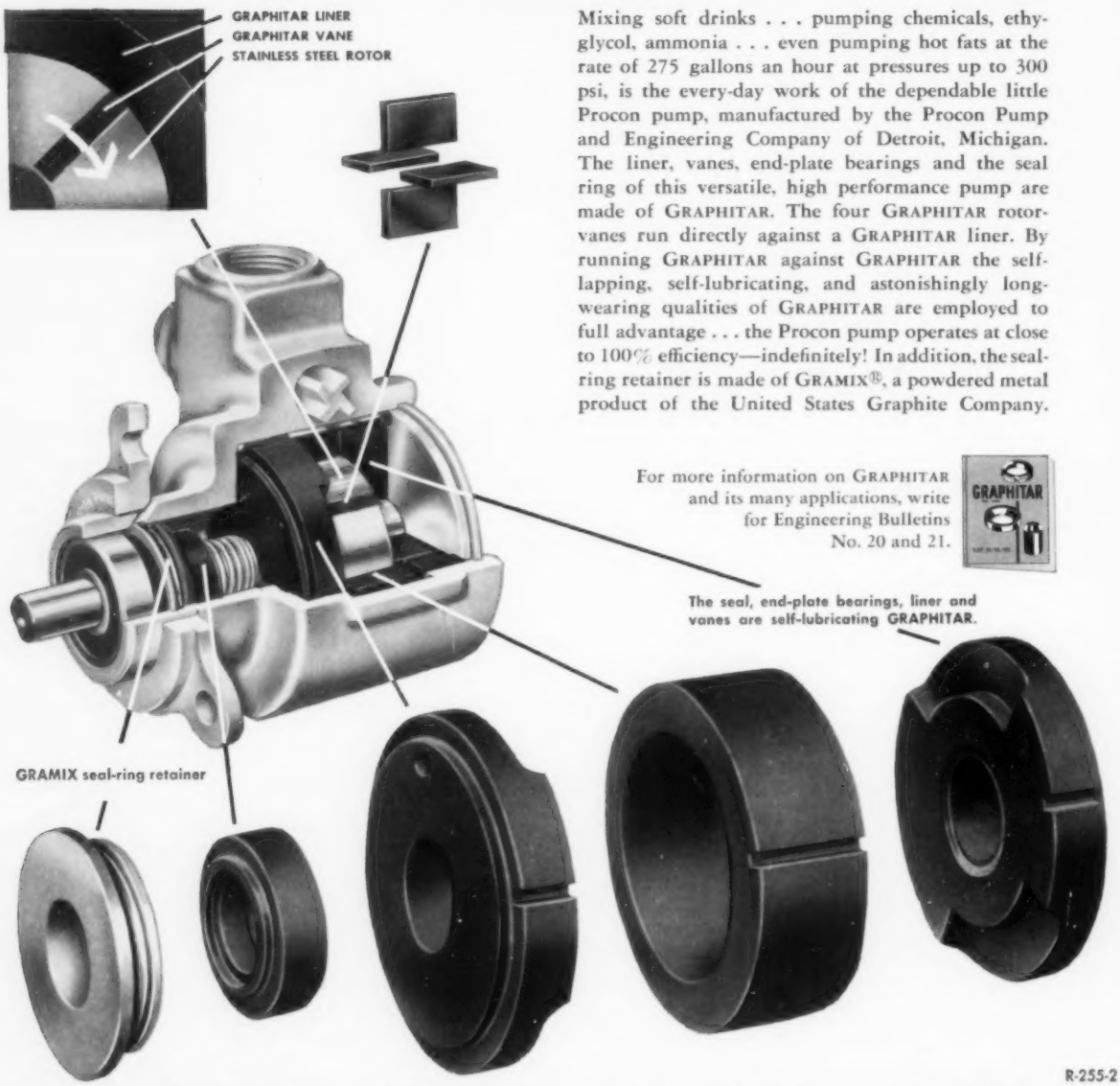
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